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STUDY,
AUTOMATION OF COMPONENT TESTING
SATURN DSV-4B

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Preface

In response to a request from the Chairman of the Systems Checkout Working Group, this report has been revised to include more detailed descriptions of the Contractor's proposed methods of bench testing stage and GSE assemblies. These data are contained in Appendices D through G.

TABLE OF CONTENTS

1. INTRODUCTION

In accordance with Saturn S-IVB Scope Change No. 1076, Change Order 41, a study has been initiated to determine the feasibility of automating the Component Test Sets used in testing the Stage and GSE Assemblies.

1.1 Scope

This study will include the general philosophy of testing utilized in the presently proposed method of Bench Functional Testing of the Stage and GSE Assemblies as well as the feasibility of a single equipment system to perform these same tasks. The report will concern itself primarily with the automatic test sets currently available, the degree of modification required to accomplish the task of the Component Test Sets, the amount of interface necessary for each Unit-Under-Test, cost and schedule considerations as well as a recommended course of action.

2. GENERAL PHILOSOPHY

The philosophy of the test equipment is dictated by the general rules relating to the usage for which the test equipment is intended. The use of this equipment will in general be in two locations, the factory checkout area and the field stations. The level of test is basically the individual component isolated from the system of which it is a part.

2.1 Factory Checkout

The factory checkout area will be used for the tests which are required as a part of the manufacturing routine. This type of testing, of course, does not preclude the fact that the Unit-Under-Test may suffer from faults such as improper wiring, faulty components, misalignment, or incorrect adjustments. A second factory type requirement is for receiving inspection of vendor items coming into the local plant. The types of tests to be performed here will assume that the item has worked properly once and will merely guarantee that

2.1 (Continued)

it still is functioning correctly. Generally, no adjustments are made in the unit because the vendor facility has made all factory adjustments.

2.2 Field Sites

At the field sites, 2 distinct types of tests are again performed. Just prior to installation in the vehicle, the unit will be tested to verify it is still functioning and is in proper alignment. This type of test generally requires only an end to end test with the proper cabling hookup. The second type of test is an analysis of a failure by a replacement of a module or some other smaller subassembly.

2.3 Level of Test

The level of test is at the component level, removed from the vehicle and divorced entirely from the larger system of which it is an integral part. Thus we will be testing assemblies and subassemblies, i.e., calibration and junction boxes, VCO's, multiplexers, translators, etc. In particular, the analysis and study are based on assemblies used on the Saturn S-IVB Stage.

3. PRESENT TEST EQUIPMENT METHODS

The present methods of testing with the existing test sets, are completely manual in operation and require high operator skill for proper execution.

3.1 Manual Test Set

The present test sets are completely manual. We define manual checkout as a group of basic instruments (VTVM's, oscilloscopes, etc.,) manipulated by a human operator. Test sequencing, test probe applications, data reading and recording, analyses of test results and detection of malfunctions are performed by a man. The proper interpretation of complex waveforms, wide ranges of voltage, current and frequency measurements are subject to human judgment. The test sets apply proper operating stimuli to the Units-Under-Test and monitor the outputs for proper responses. The instruments in the test sets will be removed at specified intervals for calibration and comparison with calibration standards.

3.2 Number of Test Sets

The various test sets are broken down into groups depending upon the assemblies which they check out and are designated as follows:

(a) Model DSV-4B-102 - PAM/FM/FM Telemetry Component Test Set
(b) Model DSV-4B-103 - Single Sideband/FM Telemetry Component Test Set
(c) Model DSV-4B-104 - Printed Circuit Card Test Set
(d) Model DSV-4B-109 - Sequencer Component Test Set
(e) Model DSV-4B-110 - Power System Electrical Component Test Set
(f) Model DSV-4B-112 - Propellant Utilization Test Set
(g) Model DSV-4B-113 - Destruct/Receiver Controller Component Test Set
(h) Model DSV-4B-114 - EBW Firing Unit Component Test Set
(i) Model DSV-4B-115 - PCM/FM Telemetry Component Test Set
(j) Model DSV-4B-252 - FM Transmitter Test Set

3.3 Summary of Requirements for Test Sets

A detailed list of requirements for the individual test sets is presented in Appendix A. A summary of the requirements for the test sets is listed below:

3.3.1 Stimuli

(a) AC power, 60 cps, 400 cps, 120V rms
(b) Regulated DC voltage 0-5V, 28V, 100V, 250V
(c) Sine wave generators 0-10 mc
(d) Square wave generators 0-1,200 cps
(e) Pulse generators 0-5 mc
(f) Ramp functions 0-1,200 cps
(g) PAM Simulator
(h) Random noise sources

3.3.2 Monitoring Instrumentation

(a) Oscilloscopes 0-40 mc
(b) Bridges .01%
(c) Counters 500 mc
(d) Recorders 0-3,000 cps

3.3.2 (Continued)

(e) DC VTVM .05%

(f) AC VTVM .1%

(g) Tunable voltmeter 500 KC

(h) Wave analyzer 500 KC

3.4 Testable Items

The following items must be tested on the Component Test Sets:

VCO and Amplifier Assembly
Slow Speed Multiplexer
Central Calibration Assembly
Central Calibration Command Decoder
Central Calibration Channel Decoder
DDAS Relay Assembly
Signal Conditioning Networks
SS Translator Assembly
Sequencer
Inverter/Converter
Propellant Utilization Electronics Assembly
Model 270 Multiplexer
Remote Sub-multiplexer
Digital Data Aquisition Assembly
Transmitter Assembly
Amplifier Assembly
EBW Firing Unit
Range Safety and Command Destruct Receiver

4. DESCRIPTION OF AVAILABLE AUTOMATIC TEST EQUIPMENT

The equipment presently available on the market is in general restricted to DC and low frequency AC testing methods.

4.1 List of Available Equipment

A description of each of the available equipments listed below is available in Appendix B.

(a) Nortronics SP-8A
(b) CTI Model 235
(c) DIT-MCO Model 610A
(d) Hughes Aircraft Company HCM-111A
(e) Bendix AN/GJQ9
(f) Dymec Division of Hewlett-Packard
(g) Aircraft Armaments, Inc.

4.2 General Comparison of Various Equipments

For a comparison of the various equipments with regards to input-output characteristics, see table 1.

5. ADVANTAGES AND DISADVANTAGES OF AUTOMATIC TESTING

5.1 General

Each possible application of automatic checkout equipment must be carefully evaluated. There is no clear cut case for or against its use in the general situation.

5.1.1 Definition

Automatic checkout equipment is, in essence, nothing more than a collection of test instruments, designed to minimize the duties of the human operator. The machine is given the task of selecting tests, recording results, collecting and analyzing data, and furnishing decisions based on test results.

5.1.2 Advantages

The primary advantage of automatic checkout equipment is that it can perform more rapidly, with greater precision and repeatability than a human: A permanent record is usually produced, and fewer less-skilled personnel are required for operation (less-skilled does not imply inadequately trained!).

MEASUREMENTS OR STIMULI / MANUFACTURER	DC VOLTS RANGE ACCURACY	AC VOLTAGE RANGE ACCURACY	RESISTANCE RANGE ACCURACY	FREQUENCY	PERIOD/TIME
HUGHES HCM-111A	Floating and buffered 0.1% including quantization	Floating and buffered 0-500V rms 0.2% including quantization	2 or 4 terminal 0-1 megohm 0.2%	0-10 mc any waveform	Controlled by program
DIT-MCO 610	2 terminal 0-39.9 volts unknown	None	4 terminal 0-1 meg unknown	None	None
DIT-MCO 720A	None	None	4 terminal 0-999 Kilohms unknown	None	None
CTI 235	Floating 0-999.9 volts 0.1%	Floating 0-999.9 V rms 0.1%	2 terminal 0-999.9 Kilohms 0.1%	0.1 cps to 1.2 mc	1.0 usec to 10^7 sec
NORTRONICS SP-8A	Floating 0-500 VDC 0.1%	Floating 0-500 V rms 0.25%	2 terminal 0-999.9 Kilohms 0.2%	0-1 mc	.01-1000 sec
GENERAL ELECTRIC Model # unknown	Floating 0-500 VDC 0.01%	Floating 0-500 V rms 0.1%	4 terminal 0-999.9 Kilohms 0.1%	0-2.5 mc	1.0 usec - 10^7 sec
MARTIN Model # unknown	Unknown	Unknown	Unknown	0-2.5 mc	1.0 usec - 10^7 sec
BENDIX AN/GJQ-9	Floating 0-999 VDC 0.1%	Floating 0-999 V rms 1.0%	2 terminal 0-1 megohm 1%	0.1 cps - 1.0 mc	1.0 usec - 100 sec
DYMEC	Floating and guarded 0 - + 1000 VDC .01%	Floating and guarded 0 - 750 V peak AC 0.15%	2 or 4 terminal 0 - 10 megohm .02% of Full Scale 0.15% of reading	0 - 10 mc or 0-510 mc	1.0 usec - 10^8 sec
AIRCRAFT ARMAMENT, INC. AN/MPQ 36	Floating 0-500 volts 0.1%	Floating 0-120 VAC, 60 and 400 cps ± 10% voltage, ± 5% Freq.	Floating 0-10 meg 0-1 meg ± .15%, 10 meg ± .5% full scale	10 cps to 80 mc	1 usec to 100 sec

TABLE 1

Sheet 1

MANUFACTURER \ MEASUREMENTS OR STIMULI	WAVEFORM ANALYSIS	INTERNAL COMPUTATION	INTERNAL STORAGE	CONTROL METHOD	PARALLEL DIGITAL	SERIAL DIGITAL	DIGITAL PROCESSING	TAPE CONTROL MODE	COMPUTER CONTROL MODE
HUGHES HCM-111A	0-20 mc repetitive 10ns sample width	Yes	Yes	Tape or computer	Zero and positive	Zero and positive	Yes	300 char/sec reversible	33,000 operations per sec. basic
DIT-MCO 610	None	No	No	Tape or punched card	No	No	No	Tape reader control	No
DIT-MCO 720A	None	No	No	Tape or punched card	No	No	No	Tape reader control	No
CTI 235	0-10 mc 5%	No	No	Tape or punched card	No	No	No	Tape reader control	No
NORTRONICS SP-8A	None	Yes, digital computer	No	Tape					No
GENERAL ELECTRIC Model # Unknown	0-2 mc repetitive	No	No	Tape	Open or closed 8 bits	No	No	Tape reader control	No
MARTIN Model # Unknown	0-2 mc repetitive	No	No	Tape	Open or closed	No	No	Tape reader control	No
BENDIX AN/GJQ-9	None	Yes, comparator	Yes	Tape	Open or closed Zero or positive	No	No	Internal clock	External
DYMEC	Any 4 parameters at clock rates to 100 mc/s	Yes, Comparator 6 decimal digits	Yes, Up to 7 decimal digits	Tape	Open or closed	No	No	Internal clock	None
AIRCRAFT ARMAMENT, INC. AN/MPQ 36	0-25 mc repetitive	No	No	Perforated tape	No	No	No	Tape reader control	No

TABLE 1
Sheet 2

MEASUREMENTS OR STIMULI / MANUFACTURER	WORD SIZE	MEMORY SIZE	INDEX REGISTERS	INTERRUPT FEATURES	COMMENTS
HUGHES HCM-111A	24 bits + sign 12 bit order	32,768 orders random access	8	Priority and I/O interrupt	With proper interfaces will be adequate for test system
DIT-MCO 610	Not applicable	Not applicable	None	None	For static module testing
DIT-MCO 720A	Not applicable	Not applicable	None	None	For static relay and cable testing
CTI 235	Not applicable	Not applicable	None	None	If properly interfaced and placed under computer control, would be adequate
NORTRONICS SP-8A	Not applicable	Not applicable	None	None	
GENERAL ELECTRIC Model # unknown	Not applicable	Not applicable	None	None	
MARTIN Model # unknown	Not applicable	Not applicable	None	None	
BENDIX AN/GJQ-9	Not applicable	Not applicable	None	None	
DYMEC	Not applicable	Not applicable	Not applicable	Not applicable	
AIRCRAFT ARMAMENT, INC. AN/MPQ 36	Not applicable	Not applicable	None	None	With proper interface, stimuli and measurement modification, it would be adequate

TABLE 1
Sheet 3

5.1.2 (Continued)

There can be no short cuts or omissions in the tests being performed since the test program is not directly under the control of a human operator.

5.1.3 Disadvantages

Automatic test equipment invariably implies higher initial cost and longer development time. It also adds complexity to a system and the complexity leads to lengthy down time. With one large automatic test system, only one particular component can be tested at any one time and if the Unit-Under-Test is malfunctioning, the entire test set is tied up until the trouble is cleared.

6. SUITABILITY OF TESTABLE ITEMS FOR AUTOMATIC CHECKOUT

6.1 Propellant Utilization Electronic Assembly

The Propellant Utilization Electronic Assembly is a very difficult assembly to adapt to automatic test and checkout. All of the input stimuli are analog and all of the outputs are analog. The measurements performed on the outputs are required to be .05% of indicated reading. The input stimuli to the P.U. Electronics Assembly are related to capacitance changes in the mass sensors (The capacitance probes that go into the LO_2 and LH_2 tanks). Of course this could be resolved to an equivalent AC voltage for an input stimuli, or a digitally programmed capacitor could be procurred.

In view of the accuracy of available automatic test equipment, it does not appear unreasonable to automate the testing of the P.U. Electronic Assembly. The major problem would be in obtaining a digitally programmed capacitor to simulate the input stimuli.

The P.U. Electronics Assembly has adequate test points brought out to the connectors on the assembly so that scanning the outputs for measurement would not be impractical. Input stimuli would be controlled digitally and the outputs converted to a binary quantity and compared to preset limits.

6.2 Power System Assembly

The power system test set is used for checking the static inverter/converter. The inputs and outputs of the converter are all AC and DC voltages. In addition, several phase measurements have to be made. Several of the test sets available are capable of accomplishing the desired results.

6.3 Sequencer Assembly

The sequencer test set monitors the sequencing relays and checks the sequencing time and level. Since the various functions of the sequencer are ON-OFF in nature, it would be a rather simple matter to sample the levels and to check their status with any one of the various automatic test sets.

6.4 DDA Assembly

The DDA assembly in general accepts pulse amplitude modulated signals, analog inputs, and discrete ON-OFF input information. Output consists of pulse coded serial trains, basically a digital data acquisition and processing system. This system lends itself to automatic testing quite readily with such a test set as the Hughes Model HCM111A.

6.5 PAM/FM Assembly

The PAM/FM assembly consists of various signal conditioning networks, voltage controlled oscillators, wide band amplifiers and mixers for assembling the 15 channels of the sub-carrier. This assembly is not difficult to setup for automatic testing and could be checked out satisfactorily by the Hughes Model HCM111A or a combination of the Dymec equipment.

6.6 Single Sideband/FM Assembly

The Single Sideband/FM assembly will be one of the more difficult to checkout with automated equipment. The Single Sideband/FM assembly could only be tested end to end. All individual tests on component cards are made by use of card extenders and the lack of available test-points at cable connectors makes an automated checkout difficult.

6.7 Transmitter Assembly

The transmitter assembly has 1 input and 1 output. The input stimuli is an analog signal and the output is a frequency which is directly proportional to the input signal amplitude. The parameters that we are required to measure are analog quantities. The measurement of the output frequency and output power into a load would entail a difficult design problem for the adaptor. However, the analog quantities could be digitized and handled in an automatic test system very easily. The tester would have to contain some internal arithmetic ability since some computation and a comparison would have to be performed.

6.8 Signal Conditioning and DAS Relay Assembly

The signal conditioning units and DAS relay assembly are checked on the PAM/FM test set. Since the signal conditioning amplifiers are analog units, they readily lend themselves to automated checkout equipment. An analog to digital converter would be all that would be required for further processing. The DAS relay assemblies are ON-OFF type switching circuits which can be automatically checked with little conversion equipment.

6.9 Calibration Unit

The calibration unit could be automated by using an analog to digital converter at the output to encode the output into binary information for calibration. A portion of the output information of the calibration is control level information and would require minimum adaptor design for automated checkout.

6.10 GSE Assembly

The GSE has self check capability which will check all of the GSE to a group of cards. The GSE self check includes several features. A check routine is put on magnetic tape and fed into the computer. The computer communicates with the various items via the computer interface unit. These items include the safety item monitor, the stimuli conditioner, the response conditioner, the DDAS ground station, the system status display, the test operators console, and the PAM System.

6.10 (Continued)

In addition, a single pulse mode of operation is provided to check all malfunctions of the GSE end items. On the dynamic mode there is a direct line to all "flip-flops." This allows maintenance without lockup of the logic circuits. On the test operator's console there are 24 switches that are used to simulate a computer message (simulates the computer I/O) and it monitors the results on 24 lights. It can look at the inputs and acknowledge the outputs. The output of the response conditioner is checked by the computer. For trouble shooting, each transmission line has a toggle switch to checkout the computer interface unit.

When the self check capability of the GSE has isolated the malfunction as far as possible, the group of suspected cards is tested on the Printed Circuit Card Test Set, DSV-4B-104. If the malfunction is such that it cannot be localized to this level immediately by the GSE itself, as might occasionally happen, roll up standard laboratory test equipment will be used to pin-point the trouble.

Since the GSE is essentially already under automatic checkout to a level, beyond which manual trouble shooting is required, no further discussion is necessary.

6.11 EBW Firing Unit

The Exploding Bridge Wire (EBW) Firing Unit requires a signal to simulate the action of 28 VDC. The output is a 2 microsecond pulse of extremely high current amplitude. The adaptor would have to present the pulse as a DC level to provide the information in a form acceptable to computer control.

6.12 Range Safety and Command Destruct Receiver

The Range Safety Receiver requires an RF signal modulated with an audio tone to actuate relays internal to the unit.. The RF signal generator would act as an adaptor and conventional measuring devices of digital information within any of the automatic test sets are satisfactory for measurement of the output parameter.

7. INTERFACE REQUIREMENTS

7.1 General

The use of automatic test equipment for component testing requires that adaptors be designed and each adaptor will be peculiar to the automatic test set selected. The adaptors represent a significant scope of work and their requirements can best be shown through a sample evaluation for a particular test set. In evaluating the various test sets, the Hughes HCM-111A appears to be the one test system most suited to our task. It will be used as the basis for discussing interface requirements. The stage electrical/electronic components that require similar stimuli and response criteria will be lumped together for these interface considerations.

7.2 Switching Assemblies

The first grouping is as follows:

(a) Sequencer Assembly
(b) FM/DDAS Relay Assembly
(c) Central Calibration Assembly
(d) Central Calibration Command Decoder
(e) Central Calibration Channel Decoder
(f) Digital Data Aquisition Assembly (DDAA)

7.2.1 The inputs consist of a large number of discretes and low frequency AC or slowly varying DC signals. The outputs are either a serial pulse train, or a series of on-off type signals. For example the DDAA inputs are a minimum of 1,200 signals and the sequencer a minimum of 60 inputs. The output lines to be monitored on the sequencer would be a minimum of 125 signals. The output lines of the DDAA would be 30 signals. These outputs have to be monitored and measured.

7.2.2 The measurements that are required fall into 4 categories:

(a) Amplitude
(b) Time, repetitive rate or frequency
(c) Resistance or impedance
(d) Serial data train

7.2.2 (Continued)

The serial data train contains synchronization words that must be recognized and after synchronization recognition, the data words must be separated out and evaluated for conformance to the input signal level.

7.2.3 The adaptor or interface unit for the stage components listed above would consist of the following:

(a) An input scanner of 1,200 channels
(b) An output scanner of 125 channels
(c) An analog to digital converter capable of 10 bit resolution and a conversion time of 100 micro-seconds
(d) An Ohms to DC converter
(e) An amplitude discriminator
(f) A frequency discriminator

The input scanner would be used to distribute the stimuli to the proper input terminals of the Unit-Under-Test. The output scanner would select the correct outputs for the test being performed. The A/D converter would be used to convert any DC voltages or levels into an equivalent binary quantity for entry into the data processor. The Ohms to DC converter would be used to convert the resistance and impedance measurements into an equivalent DC voltage for further conversion to a binary quantity for entry into the automatic test set. The voltage or amplitude discriminator would be used to detect the presence of an "ON" type signal for the discretes or switch closure type signals.

The frequency discriminator would be used to convert the GSE VCO output from the DDA assembly to a DC level that would be equivalent to the serial pulse train driving the VCO in the DDA assembly.

7.2.4 For the units listed above, the possible test sequence would be similar to this: The test program would be put on tape and the tape unit would load the high and low limits for each of the tests to be performed into the memory unit of the tester. The test set would then control the input selection and further select the proper stimuli for the test being performed. At the same time, the tester would select the proper output to take the response of that particular test and route it to the converter or converters required. It would

7.2.4 (Continued)

then take the measured quantity and route it to the proper memory slot and perform a comparison on the quantities, make a decision as to whether it is high, low, or within the test limits, and display and either print out or record the test results. If a "no go" or malfunction occurs, the tester will be programmed so that it immediately switches into a manual mode of operation and remains on this particular test step until the malfunction is cleared. As soon as a "go" signal for this step is generated, the tester would be programmed so that it will resume the automatic mode. See figure 1.

7.3 <u>Power Systems (Static Converter/Inverter) and P.U. Electronics Assembly</u>

The power systems and propellant utilization electronics assembly are grouped together for 1 interface unit.

7.3.1 The power system has 1 input requiring 28 volts DC and provides 16 outputs. The propellant utilization electronics assembly has 8 inputs and 28 outputs. The stimuli required for the P.U. assembly inputs are analog quantities and the outputs for both units are analog quantities.

7.3.2 Some of the outputs are AC voltages and currents. The balance are either DC voltages or resistances. The measurement accuracy for the P.U. assembly responses are 0.05%.

7.3.3 The instruments and equipment required for the adaptor are listed below:

(a) A 25 channel guarded scanner for inputs selection
(b) A 50 channel guarded scanner for output selection
(c) An AC/Ohms to DC converter with a guarded and shielded input network.
(d) An analog to digital converter capable of generating a 13 bit binary word plus sign bit and be capable of a conversion every 100 microseconds.
(e) A phase difference to time converter
(f) A digitally programmed capacitor

An alternate approach would be to use the Dymec 2401A integrating DVM, since the 2401A is a companion instrument to the AC/Ohms to DC converters and provides a 4 line BCD output for each of the decimal digits and measures to 5 decimal digits. It would also be used as the analog to digital converter. The further

Figure
Interface unit

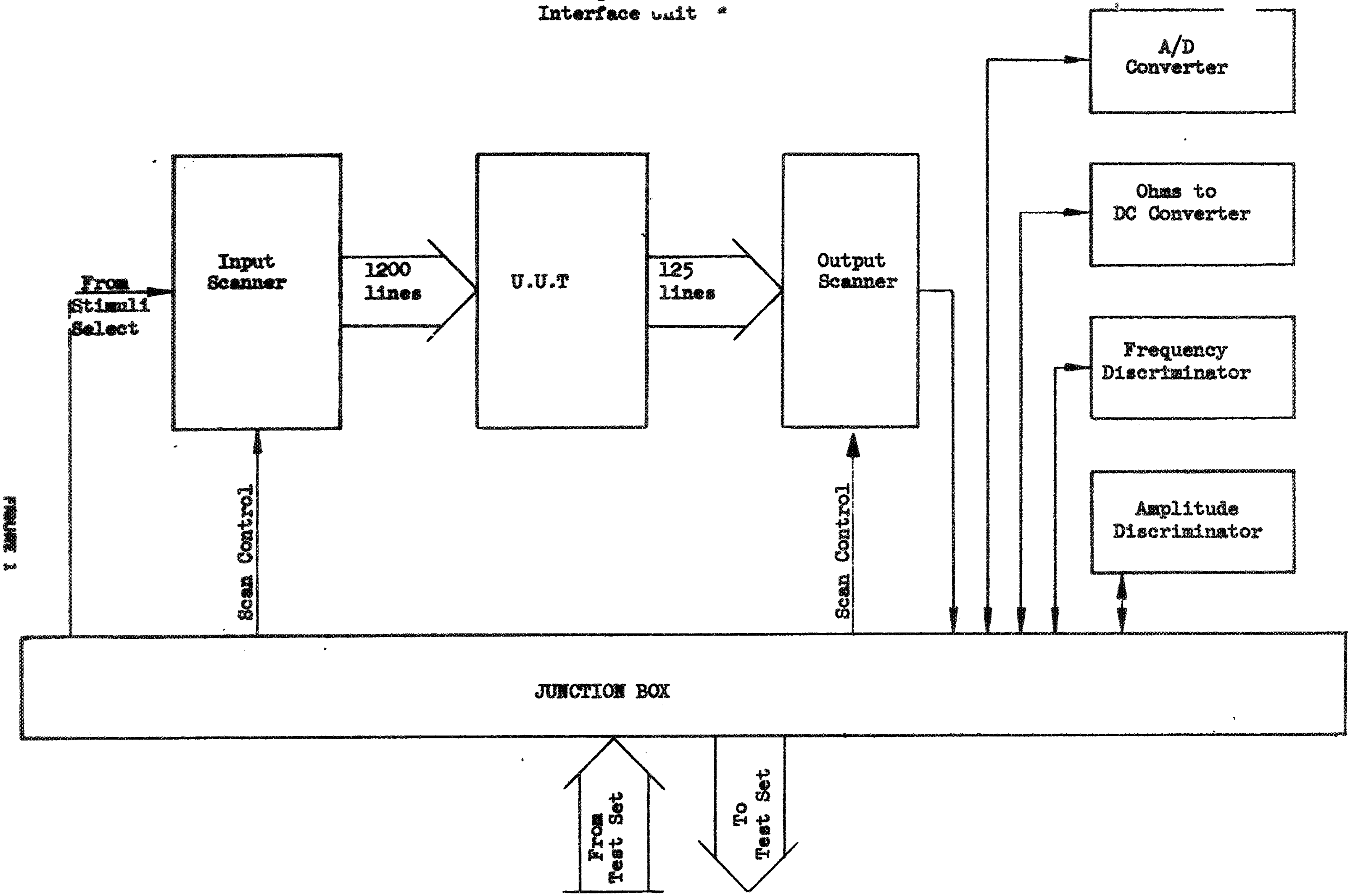

FIGURE 1

1. BBA Assembly
2. Main and submux's
3. DDAS Relay Unit
4. Central Calibration Command Unit
5. Central Calibration Command Decoder Sequencer

7.3.3 (Continued)

attraction is that it has a floating guarded input.

The error of the combination AC/Ohms to DC converter and the DVM for frequencies from 20 cps to 10 KC is .05% of full scale on AC voltages and .02% of full scale on resistance. The measurements on the power system assembly are to be made to at least 1% accuracy and the measurements on the P.U. electronics assembly are to be made to 0.05%. All the inputs with the exception of 1 are DC or AC and the outputs are DC, AC, or phase measurements.

7.3.4 The adaptor will have to accept and apply to the Unit-Under-Test, DC, AC, and incremental changes in capacitance and take the outputs and apply them to the proper instruments for digitizing. For the DC measurements, the voltage to be measured would be applied to either the A/D converter or to the DVM, if used. For the AC voltages or resistance measurements the signal path would be to the AC/Ohms to DC converter and then to the A/D converter or DVM, whichever is used. A floating and guarded system would be required. All of this could be accomodated in the adaptor unit. The floating and guarded system is required because of the level of the AC and DC measurements.

The digitally programmed capacitor would be assembled from precision capacitors and a relay matrix. The relay matrix would be used to pull the proper capacitors into the bridge circuit in the Propellant Utilization Electronics Assembly input. The capacitance values are tabulated below:

	LO_2 Tank Probe	LH_2 Tank Probe
EMPTY CAP	710 PF	425 PF
FULL CAP	870 PF	620 PF

A program of 6 points is used for linearity tests. For the LO_2 simulator capacitance, increments of 32 PF would be required and for the LH_2 simulator, capacitance increments of 39 PF would be required. By building up the probe simulators, a floating guarded system could be obtained and in this manner prevent noise and induced signals from effecting the measurement and test.

7.4 The Signal Conditioners and Low Level Amplifiers

The signal conditioners and low level amplifiers have as inputs the same generic types of signals, and their outputs have the same general signals and signal levels.

7.4.1 The signal conditioners inputs are either the 0-5 volt or 0-60 mv signal. It conditions these inputs for use in the PAM System or the PCM System. The amplifier accepts a low level signal and brings it up to a 5 volt full scale output for use in the PAM or PCM assemblies. At this time there is insufficient information available on the parameters of the signal conditioners and amplifiers to discuss them in greater detail. Therefore, we will discuss in a general way how to test the signal conditioners and amplifiers. Since part of the inputs will be low level, a 4-wire input system will be used (a floating and guarded input system). This will protect against noise pickup. Also by using a 4-wire system, we can simulate the point we desire.

7.4.2 The equipment required for the adaptor (interface unit) is listed below:

(a) A 25 channel floated and guarded input scanner
(b) A 25 channel floated and guarded output scanner
(c) An A/D converter
(d) An AC/Ohms to DC converter
(e) A programmable precision resistor
(f) A precision current source

The input and output scanners are used to select the proper input and output channels for the test being performed. The precision resistor is used to substitute a resistance that is the equivalent to the transducer resistance to complete the input circuit to the Unit-Under-Test. The AC/Ohms to DC converter is used for converting the AC or Ohms measurements to an equivalent DC voltage. The A/D converter is used to convert all the DC voltages to the equivalent binary quantity for entry into the test set. The current source is used as bridge excitation for the input circuits.

7.4.3 The probable method of checking the signal conditioning would be to apply discrete frequencies of known amplitude to the inputs and compare the input amplitudes with output amplitudes to determine the breakpoint and roll off characteristics of the signal conditioning networks. The same method could be used for the linearity and insertion loss tests by using frequencies below the 1st corner on the signal conditioning networks. This same technique could be used for evaluating the amplifiers.

7.5 PAM/FM Assembly and FM transmitter Assemblies

The PAM/FM assembly consists of 15 channels of VCO's and the summing amplifier. Since, the pre-emphasis taper must be set when the VCO assembly is loaded into the transmitter, it is reasonable to test the 2 assemblies together.

7.5.1 The summing junction of the amplifier is a psuedo summing point and is an integral part of the input circuit of the wide band amplifier. There is no way in the existing assembly to disable the VCO's individually so that evaluation of the individual VCO's can be performed. The evaluation and test of the assembly will have to be performed on the composite video signal that is available at the output of the wide band amplifier. The VCO assembly will be checked with the transmitter. This would assure that a compatibility between the VCO assembly and the transmitter exists. However, one of the exciters would have to be included as a part of the interface unit, so that when only a VCO assembly was being checked, the test link would be completed.

7.5.2 The equipment required for the interface unit is listed below:

(a) 15 channel input switching network
(b) 15 signal generators (fixed frequency capable of 5 volt P-P sine-wave output).
(c) Dummy RF load for 215/260 mcs and 25 watts load.
(d) RF attenuator
(e) Automatic tuning telemetry receiver
(f) Programmable FM discriminator
(g) Exciter unit for RF assembly

7.5.3 The 15 channel input switching network is used to select the various input signals and apply them to the inputs of the VCO assembly. The 15 signal generators are used to provide a signal of the proper data frequency and amplitude to each of the individual VCO's. The dummy load is used to terminate the transmitter in a resistive non-radiating load and also to determine transmitter output power. The RF attenuator is used to tap off a portion of the RF energy and apply it to the receiver input at a safe amplitude. The telemetry receiver is used to detect the RF carrier and to further prepare the signal for application to the discriminator. The discriminator is used to separate the various VCO channels out of the composite signal for further use in evaluating the performance of the assemblies. The RF exciter unit is used to complete the measurements link when a VCO assembly is to be tested without the transmitter assembly. The frequencies to be measured are routed to the measuring instruments in the test set. However, the frequency measurement capability of the tester will have to be modified to accept and determine frequencies in the 215 to 260 mcs region. The present state of the art will permit direct measurement to 512 mcs. It is pointed out that considerable care and state of the art engineering practice will have to be employed in the interface design due to the frequencies involved.

7.6 Exploding Bridge Wire Firing Unit

The EBW Firing Unit accepts DC and converts this DC to a high energy single pulse.

7.6.1 The input circuitry presents no unusual interface problems. The voltage can be programmed directly and the current measured using a small sampling resistor. The time measurements are level sensitive, both the charge and discharge times. This measurement can be implemented using a Schmitt Trigger arrangement. The resistance measurement can be made directly with sufficient accuracy.

7.6.2 The output represents a high energy pulse for a short time and does present some unusual problems. A possible approach is to utilize 2 sensors, 1 set low and 1 set high and have these implement a "go-no go" arrangement. The pulse width and undershoot would also have to be measured. This could be accomplished by zero level detectors and a counter.

7.7 Range Safety and Command Destruct Receiver

The input to the receiver requires a tone modulated RF signal. Similar interface problems of the PAM/FM assembly and Transmitter assembly are present here, also. The inputs to the receiver would require both an RF signal generator and tone modulator as part of the automatic test set. Measurements on the output will require little interface since they are merely relay closure and voltage amplitudes.

7.8 SS/FM Assembly

The Single Sideband/FM Assembly does not lend itself for automatic testing other than an end to end test. It could, however, be mated with the transmitter and go through the same technique as noted in 7.5.3 and use the single sideband demultiplexer in place of the discriminator.

7.9 GSE

The GSE already has computer controlled self test features. The level of fault isolation is such that under this system, printed circuit board checkout capability is all that is required.

8. COST CONSIDERATIONS

Component checkout under the control of automatic checkout systems can be more complex than is justified by the expense of the system and by the advantages gained over the use of manual checkout equipment. Mechanization of the component stimuli can be very expensive. A test set operator (whose attendance is required for setup) may be able to manually apply the stimuli merely by positioning a control, thus eliminating the requirement for costly programmable stimuli. Mechanization of the response sensing can be very expensive. This is particularly true where the response may be a mechanical motion which is slow enough to allow direct human interpretation. It may be determined from experience and a reliability analysis of the components, and the number of components per system, that the number of tests to be performed does not justify the design of buffering or adaptor equipment to implement automatic checkout of output data and the input stimuli.

8. (Continued)

Manual checkout is slow but inexpensive and reliable. Special assemblies, relegating some of the routine steps to switching circuits or recording devices may be included in manual testing, but the operator is required for more than 50 per cent of the test period. Component test equipment has been found to have low usage rates. This has been established through experience with their roles on space programs such as Thor and Saturn S-IV. Component functional testing is rarely time critical or on a high volume basis in space programs. To provide for a great number of tests in small periods of time through automation will be expensive in view of the propability of the test set being unused for large periods of time when test probe applications become necessary.

The cost of an automated test facility, the detailed programming involved, the lengthy lead time for buffering and adaptation research, as well as development and delivery, are serious draw backs to other than a manual approach. Although a considerable number of individual test consoles and a large group of specially trained operators are needed for manual component checkout, the time between contract approval and delivery can be reduced. Thus, the general-purpose test equipment also lends itself to valuable service during early development and production work. The test equipment used in the manual approach is generally all commercially available equipment, with little or no design cost involved. When a program ends the test consoles can be dismantled and the test instruments used in a new program. The cost involved in engineering time for manual component test sets is relatively small compared to that for automatic test equipment. In the manual approach, the design is a matter of selecting the proper test instruments and packaging them into a console along with 1 or 2 panels designed for switching circuits.

9. SCHEDULE CONSIDERATIONS

The schedule for the manual component test sets is timed to a vehicle or an activity. The first group of component test sets is timed to the factory checkout of the All-systems vehicle at Huntington Beach. This requires that the component test sets be designed, built, delivered, and checked out by April 1964. The second group of component test sets is timed to the All-system vehicle installation at the Sacramento Field Station. This requires their delivery and installation by July 1964. The third group of component test sets is timed to the vertical assembly building, Complex 39 at AMR and the first flight vehicle. This requires delivery and installation by January 1965. Various component test sets such as DSV-4B-110 and DSV-4B-112 are required even earlier for the Battleship Program at the Sacramento Field Station. This requires their delivery and installation by January 1964.

Phase I reviews have been presented to NASA on component test sets DSV-4B-102, 103, 104, 109, 110, 112, and 252. Production drawings have been started on these models and hardware design is essentially 3 months in progress and equipment is being ordered. The impact of redirecting the program at this time for automatic component test equipment design would be such as to disrupt the schedule by a minimum of 18 months. The lead time required for the automatic test set would be approximately 1 year. The adaptor and buffering design would require a minimum of 1 year of engineering alone. This excludes all support functions such as drafting, technical writing, and test programs writing, etc. The system checkout and integration of the automatic test equipment would require a minimum of 6 months. In view of these time estimates and a projected contract approval date of September 1963, the automatic test equipment could not be available at Huntington Beach before February 1965.

This would imply that due considerations would have to be given to automatic test equipment as a second generation equipment for this program. That is, manual equipment design and production would be allowed to continue as contracted, and automatic test equipment phased in at a later date.

10. CONCLUSIONS

To determine the degree of automation required in a given space-support program, key factors in the checkout approach must be evaluated and trade-offs granted. Such factors as available test time, equipment down time, number of space vehicles to be tested, and cost are interrelated.

10.1 Suitability of DSV-IVB Program for Automatic Checkout Equipment

If we analyze all of the advantages of automatic test equipment, when applied specifically to the Saturn S-IVB program, certain facts stand out. In the area of component test sets, the speed of testing is not so very important because the flow rate of components is generally so low that many days may elapse before identical units are tested. The units themselves will generally require manual intervention during the test sequence for adjustments which will cut down the speed of the tests. In general, the components are not time critical when tested on the component test sets and therefore speed is not essential. The repeatability of tests and the written record produced by the automatic tester are features which can be implemented to some extent on the manual tester, but this would require some digression into semi-automatic techniques. The versatility of the automatic tester is maintained only so long as the adaptor is flexible. In general, the adaptors required for this program will be made for a specific application and if a hardware change is encountered, the adaptor will usually have to be modified. Troubleshooting on automatic equipment becomes difficult because it is difficult to get the operator into the loop to isolate a fault which is not part of the program.

10.2 Suitability of Automatic Checkout Equipment for the DSV-IVB Program

It is apparent that several of the various pieces of automatic checkout equipment could be adapted to the DSV-IVB program, depending on how much modification and what type of adaptors we are willing to tolerate. In all cases, such components as the SSB/FM Translator Assembly could only be tested to assure that the most basic facts of the total system's effectiveness were monitored. The CTI 235 could be expanded to handle the checkout

10.2 (Continued)

if under computer control. The Nortronics GP-8A does not have an internal memory and is basically a low frequency or static test system which is tape programmed. This also applies to the DIT MCO units. The Dymec equipment would require some additional arithmetic units and a computer control to become a complete automatic checkout system. A nominal amount of development time would also be required to assemble the Dymec units into a complete system. The Hughes Aircraft Company HCM-111A Automatic Tester seems to be the one most suitable presently available system, and a thorough discussion of the interface required of this has been presented in Section 7, Interface Requirements.

10.3 Cost Considerations

Automatic checkout equipment only becomes less costly as a greater number of tests are required in a shorter period of time. As more tests are needed to provide information about a system, automatic test equipment becomes more desirable. The flow rate and number of tests required per assembly in this program do not seem to justify the many times the cost of manual equipment.

10.4 Schedule

Automatic checkout equipment could not be placed into the program until sometime in 1965 as second generation equipment.

11. RECOMMENDATIONS

It is recommended that automatic checkout equipment should not replace the present component test sets at this time due to the impact on committed schedule requirements. Any utilization of automatic checkout equipment should be second generation and the advantages gained versus the dollar cost do not at this time justify such action.

DESCRIPTION OF EACH OF THE PRESENT COMPONENT TEST SETS

1. DSV-4B-102 - TEST SET, TELEMETRY COMPONENT, PAM/FM/FM

The PAM/FM/FM Telemetry Component Test Set is capable of calibrating and trouble shooting the following telemetry components:

a. Voltage controlled subcarrier oscillator
b. Summing amplifiers
c. Slow speed multiplexer
d. Central calibration command unit
e. Central calibration command decoder
f. Central calibration channel decoder
g. Signal conditioning network

The test set consists of a three-bay console with a desk type front.

The PAM/FM/FM Telemetry Component Test Set provides the stimuli and monitoring equipment necessary to adequately calibrate and trouble shoot the telemetry components. This requires the capability of performing the following tests on the respective telemetry components.

a. VCO and amplifier assembly

1. VCO center frequency adjustment
2. VCO upper and lower band edge adjustment
3. VCO static linearity measurement
4. VCO input impedance measurement
5. VCO dynamic linearity measurement
6. Amplifier gain adjustment
7. Amplifier bandwidth measurement
8. VCO output level adjustment
9. Cross talk measurement
10. Calibration circuit verification

b. Slow Speed Multiplexer

1. Input impedance measurement
2. Output timing and sequence measurement
3. Output amplitude measurement

c. Central Calibration Command Unit

1. Output line amplitude and timing measurement
2. Calibration buss amplitude and timing measurement
3. Output line sequence measurement
4. Preflight/Inflight operation verification

d. Central Calibration Command Decoder

1. Channel command line continuity measurement
2. Mode line amplitude measurement
3. Rack output amplitude and timing measurement

e. Central Calibration Channel Decoder

1. Output line amplitude measurement
2. Output line latching ability verification

f. Signal Conditioning Networks

1. Amplifier

   (a) Gain adjustment
   (b) Upper cutoff frequency measurement
   (c) Zero adjustment

2. Bridge

   (a) Zero adjustment
   (b) Resolution verification

3. Level Shifter

   (a) Output amplitude measurement
   (b) Linearity measurement

4. Summing Networks

   (a) Output amplitude measurement
   (b) Output sequence measurement

The test set contains the necessary interface to verify the operation of the telemetry component assemblies as well as the cards or modules.

The operation of the PAM/FM/FM Telemetry Component Test Set is entirely manual, with all controls and interface on a control panel located at the approximate center of the test set. All of the appropriate stimuli as well as the outputs and necessary interconnection to Unit-Under-Test are provided by cables which are brought out from the control panel.

The test set controls and monitors all DC operating power supplied to the Unit-Under-Test. This includes current control capabilities as well as voltage control.

Test signals supplied to the input of the Unit-Under-Test are selected by the input signal selector. This group of signals includes a variable frequency sine wave, ramp function, square wave, adjustable DC levels, various logic levels, and logic pulses.

The input selector selects the desired inputs to the component or group of components under test. Working in conjunction with the input selector is the output selector. This selects the complimentary output for the selected input.

The instrument selector is capable of controlling and directing the voltmeter, oscilloscope, discriminator, spectrum analyzer, and counter. These instruments are controlled either jointly or independently of each other. Thus several outputs and/or inputs may be monitored simultaneously. Wherever practical the monitoring instruments are capable of performing differential measurements.

With 115 V $\pm$ 10%, 60 cps $\pm$ 3% external power applied to the PAM/FM/FM Telemetry Component Test Set, it is capable of supplying the following stimuli to the Unit-Under-Test:

a. 24-32 VDC ± 0.2%, 10 amp, remotely programmable with current limiting capabilities.
b. 0-32 VDC ± 0.1%, 1 amp, remotely programmable with current limiting capabilities.
c. A continuously adjustable 0-5 V p-p, 5 cps to 100 K cps sine wave into a 5 K load.
d. A 0-5 V p-p ramp function whose pulse width is approximately 0.1 second.
e. A logic pulse 0 to 21 V p-p with a 4 msec. duration

All monitoring equipment operates from the 115V, 60 cps external power applied to the PAM/FM/FM Telemetry Component Test Set. It has the following measurement capability:

a. A switchable discriminator unit capable of demodulating a single channel from the composit PAM/FM/FM signal. This signal consists of the standard IRIG channels 1 through 14 plus a 70 kc signal with a 30% deviation. The composit signal input level will be a minimum of 1.0 volts rms.
b. A 40 mc oscilloscope with a 50 mv sensitivity, dual trace plug-in unit.
c. A 100 kc counter with 1 part in 10^5 accuracy, input Z $\geq$ 0.5 megohms.
d. An AC/DC voltmeter with differential measurement capabilities. AC accuracy ± 0.2% and DC accuracy ± 0.05%.
e. A low frequency spectrum analyzer continuously variable from 100 cps - 100 kc, input Z $\gtrsim$ 50 K ohms.

2. DSV-IVB-103 - TEST SET, TELEMETRY COMPONENT, SSB/FM

The SSB/FM Telemetry Component Test Set is capable of calibrating and trouble shooting the Single Sideband Translator Assembly. This includes the capability of conducting an end to end test of the entire assembly. This will insure a completely verified system for installation in the vehicle.

The test set consists of a three-bay console, 2 desk top bays and a center bay with a shelf on the front, 30" above the floor.

The SSB/FM Telemetry Component Test Set provides the stimuli and monitoring equipment necessary to adequately calibrate and trouble shoot the Single Sideband Translator Assembly. It contains the necessary interface to verify system operation, the performance of the individual PCB's and the 2 external modules of the Single Sideband Unit. For end to end checkout and calibration, the interface consists of cables. For individual PCB fault isolation and spare card verification, a printed circuit board receptable assembly is provided. Extender cards are utilized to aid in the individual PCB checkout as well as for system calibration. The 2 external modules on the top of the Single Sideband Translation Assembly must also be checked out individually. These modules contain a wideband isolation amplifier, and the relay logic for calibration. In order to meet this requirement, cables and test points are provided on the control panel.

The operation of the SSB/FM Telemetry Component Test Set is entirely manual, with all controls and interface on a control panel located at the approximate center of the test set. The SSB/FM Telemetry Component Test Set has 4 levels of operation:

a. System checkout
b. System calibration
c. PCB verification
d. Module verification

For Single Sideband System checkout, all of the appropriate stimuli, as well as the output and necessary interconnection to the Unit-Under-Test, are provided by cables which are brought out from the control panel to the connectors of the Single Sideband Translator Assembly. The test is accomplished with the package closed.

For calibration purposes, utilizing the same interface cables, the Single Sideband Translator Assembly is opened and card extenders are inserted to make adjustable components and test points accessible. For individual PCB verification, a universal PCB connector mounted on the control panel with a card extender, is utilized as interface with the required stimuli and monitoring equipment. For individual module verification, the wide-band amplifier module or the logic module with its associated test points and cables connected to the control panel provide the necessary interface with the required stimuli and monitoring equipment.

With only 115 V ± 10%, 60 cps ± 3% external power applied to the SSB/FM Telemetry Component Test Set, the test set is capable of supplying the following stimuli to the Unit-Under Test:

a. 24-30 VDC ± .3% 1.5A, remotely programmable, with short circuit protection.
b. 15 non-coherent noise sources at 5 V p-p, 10-3,000 cps into a 100 K resistive load.
c. A continuously adjustable 0-5 V p-p, 50 cps to 560 KC wave into a 5 K load.
d. A remotely controlled 20-3,000 cps continuous sweep sine wave of 5 V p-p into a 5 K load.

The SSB/FM Telemetry Component Test Set also contains the following monitoring equipment:

a. A switchable Single Sideband Demultiplexer unit capable of demodulating the composite SSB/FM Signal. This signal consists of the 15 3 KC wide information channels spaced 1.74 KC apart and covering the frequency range 1.74 to 71.1 KC, the special service channel of .05 to 1.2 KC, and the pilot tone of 75.83 KC. The composite signal input level is 1.0 volts rms across 330 ohms. An automatic gain control maintains the output to within ± 1.0 db for a 26 db change in input level. The output level of each channel is 50 ma peak into 330 ohm load.

   A provision for phase lock and an alarm in case of loss of phase lock is provided. Sufficient monitoring instrumentation is included to display the carrier tones, channel outputs, pilot inputs, etc. Power supplies are self contained so that only 117 volts, 60 cps is required as an input.

b. A 40 mc, 50 mv sensitivity oscilloscope with dual trace plug-in capability.

c. A 100 cps - 600 KC continously variable spectrum analyzer, input $Z \geq 50$ K ohms.

d. A 5 mc counter with 1 part in 10^5 accuracy, input $Z \geq .5$ megohms.

e. A DC nullmeter, with .05% DC accuracy and 4 place resolution.

f. An AC VTVM with a direct reading db scale and -70 db sensitivity.

g. A frequency selective voltmeter, covering the range 1 KC - 1.5 mc, band pass 200 cps.

h. A 2-channel visicorder having 1.10 mv inch sensitivity and linear over 0-3,000 cps.

3. DSV-IVB-104 - PRINTED CIRCUIT BOARD TEST SET

The printed circuit board test set is capable of performing all of the required tests for fault isolation on the printed circuit boards used in the Saturn S-IVB GSE. The criteria for the design of the PCB test set is to provide test capability for digital, pulse, or analog type circuitry and to further provide dynamic test capability as a means of fault isolation. The test set is capable of fault isolation to a part or group of parts such as the resistors, capacitors, and transistors associated with a circuit.

The function of the printed circuit board test set is to evaluate the performance of the printed circuit boards, to detect the malfunctioning circuit and to isolate the fault. The test set applies the operating voltages and stimuli to the inputs and monitors the response on the outputs.

The printed circuit board test set is contained in 2 77" racks with a work table extending the full width of the racks and spaced approximately 30" from floor level.

The printed circuit board test set contains all the test equipment and adaptor cards required to test and trouble shoot the Unit-Under-Test. The test set applies stimuli to the proper input terminals, applies operating DC voltages to the proper terminals and monitors the outputs. The test set selects the required stimuli, operating voltages, and monitoring equipment by use of a switching network. The terminals on the printed circuit board are selected by a combination of adaptor boards and switching networks. By application of the required stimuli to the input terminals on the Unit-Under-Test, and use of the proper monitor on the output terminals, the Unit-Under-Test is evaluated in a dynamic mode.

The printed circuit board test set is manually operated. The stimuli generator, indicators, and monitors are selected by switching networks. The inputs and outputs on the Unit-Under-Test are selected by adaptor boards and switching networks. The proper loads for the circuit are on the adaptor boards. When testing digital type PCB's, the stimuli generator is a double pulse generator. The output monitor is a dual trace oscilloscope. The stimuli are selected by the stimuli selector switch and the monitor selected by the monitor/indicator selector switch. The selected stimuli, monitors, and DC operating voltages are connected to a receptacle on the work table. The adaptor card is plugged into the receptacle and the Unit-Under-Test is plugged into a receptacle on the top of the adaptor card. The adaptor applies the DC operating voltages to the proper pins on the Unit-Under-Test, the stimuli are routed to the correct inputs, and the outputs are connected to the monitor by a multi-section selector switch on the adaptor.

For testing the analog type PCB's, the same sequence is used. However, the stimuli and monitor are selected in accordance with the type PCB being tested.

Adaptor boards are used so that when testing PCB's requiring fast rising waveforms, there are no long leads involved and no degradation of the wave form occurs.

After the fault on the PCB is isolated to a particular circuit on the UUT, probing is undertaken to further isolate the fault to a part or group of parts. The test set contains as stimuli:

a. Sine Wave Generator - the sine wave generator has the following minimum performance requirements:

1.	Frequency range	10 cps - 10 mc
2.	Calibration accuracy	± 2% 10 cps - 100 KC ± 3% 100 KC - 10 mc
3.	Output	3V rms into 600 ohm
4.	Source impedance	600 ohms
5.	Frequency response	± 1 db 10 cps - 10 mc when terminated 600 ohms resistive
6.	Distortion	1% 10 cps - 100 KC 2% 100 KC - 1 mc 5% at 10 mc
7.	Output monitor	VTVM to monitor input to attenuator
8.	Output attenuator	0 - 50 db in 10 db steps accuracy of ± 1% when terminated in 600 ohm

b. Pulse Generator - the pulse generator has the following minimum performance requirements:

1.	Repetition rate	2 cps to 2 mc continuously variable
2.	External trigger	unit triggers from an external source by a ± 20 volt pulse at repetitive rates up to 2 mc.
3.	Delay	0.0 usec. to 10,000 usec. continuously variable in 5 ranges
4.	Width	0.05 usec. to 10,000 usec. continuously variable in 5 ranges
5.	Amplitude	50 volt into 50 ohm
6.	Attenuation	0 - 60 db continuously variable
7.	Rise time	.015 usec. variable to 1 usec.
8.	Fall time	.015 usec. variable to 1 usec.
9.	Polarity	positive or negative
10.	Overshoot and undershoot	5% maximum

The pulse generator shall furnish pulse pairs with the above mentioned characteristics. The first pulse occurs at time = 0, the second pulse is delayable from 0.5 usec. to 10,000 usec. with respect to the leading edge of the first pulse.

c. Low Frequency Function Generator: The low frequency function generator has the following minimum performance requirements:

1.	Frequency range	0.008 cps - 1,200 cps
2.	Calibration accuracy	3%
3.	Frequency stability	1% including warmup
4.	Output amplitude	30 volts p-p into 4 K ohm
5.	Internal impedance	40
6.	Sine wave distortion	2% maximum
7.	Output system	isolated from ground
8.	Frequency response	constant within 0.2 db

d. Power Supplies: The test set contains 4 variable voltage regulated power supplies which furnish the operating voltages for the Unit-Under-Test. The power supplies have characteristics as follows:

1.	Output voltage	0 - 50 VDC
2.	Output load current	0 - 2A DC
3.	Output impedance	.01 ohm DC - 1 KC .05 ohm 1 KC - 100 KC
4.	Regulation	.05% for step load .05% against line changes of ± 10 V rms
5.	Response time	50 usec. for step load change
6.	Stability	.05%
7.	Short circuit protect	Continuously variable
8.	Ripple	Less than 0.5 mv rms at full load and low line

The test set contains monitoring and indicating devices as outlined below:

a. Wide Band Oscilloscope - The oscilloscope with the appropriate plug-ins displays the various output waveforms from the Unit-Under-Test. The oscilloscope characteristics are listed below:

1.	Vertical passband	DC - 40 mc
2.	Rise time	.009 usec
3.	Calibrated deflection factor	50 mv/cm to 20V/cm
4.	Calibrated sweep range	0.1 usec./cm to 5 sec./cm
5.	Accelerating potential	12 kv
6.	Sweep magnifier	10 X
7.	Signal delay	0.2 usec.

8. Must accept various vertical amplifier plug-in units.

b. AC/DC Vacuum Tube Voltmeter - The VTVM measures and indicates the operating voltages, and outputs from the UUT. It has minimum performance capability as outlines below;

1.	Voltage range	DC 0 - 500 VDC AC 0.05 - 500 VAC
2.	Accuracy	DC ± .05% of input voltage from 0.1 - 500 V ± 0.1% of input voltage from 0 - 0.1 volts. AC ± 0.2% of input voltage from 0.5 - 500 volts over 30 cps to 10 KC frequency range
3.	Input impedance	DC infinite at null AC 1 meg. shunted by 25 mmf
4.	Reference	Standard cell

c. Ohmmeter - The ohmmeter measures the various circuit resistances on the UUT. It shall have as a minimum the following performances:

1.	Resistance range	9 decade ranges from 1 ohm - 100 megohm center scale overall range from .05 ohm to 5,000 megohms
2.	Accuracy	± 5% of reading from 0.2 ohm to 500 megohm ± 10% of reading from

0.1 - 0.2 ohm and from 500 megohm
to 5,000 megohm

The test set contains all the necessary switching functions to select the proper stimuli generators, monitoring devices, and indicators.

4. DSV-IVB-109 - SEQUENCER TEST SET

The overall goal of the sequencer test set is to provide testing of the S-IVB Sequencer and the FM/DDAS Relay Assembly.

The Sequencer Test Set is a 2-bay unit. The power required is 115 VAC $\pm$ 10%, 60 cps $\pm$ 3%, and 1,200 VA single phase. Inputs received from the S-IVB sequencer and the FM/DDAS relay assembly consist of +28 VDC signals which will be applied to lamps on the test set to indicate the presence or absence of a signal.

The outputs to the S-IVB sequencer consists of +28 VDC $\pm$ 1 VDC signals for simulation of the S-IVB stage inputs and + 28 VDC $\pm$ 1 VDC, 25 ms $\pm$ 5 ms pulses to simulate inputs from the Guidance Section. Outputs to the FM/DDAS relay assembly consists of + 28 VDC $\pm$ 1 VDC signals for relay operation.

The + 28 VDC is used for talk-back in testing the 2 units. Also, a +11 VDC is provided to test the arc suppression circuits for each relay circuit.

The control panels and measuring equipment consist of the following:

a. Patch Panel - Its purpose is to provide for routing the inputs and outputs of the Unit-Under-Test to the various panels and drawers and to provide for rapid changing of the test set with sequencer changes.
b. Power Supply - Its purpose is to provide +28 VDC for test set and sequencer test power.
c. Switch Panel - Its purpose is to control the test sequence and the type of test to be performed on the Unit-Under-Test.

d. Sequencer Control Panel - Its purpose is to provide inputs to and monitor outputs from the S-IVB sequencer.

e. VTVM - Its purpose is to test the T/M resistors and the arc suppression circuits.

The Unit-Under-Test is the S-IVB sequencer modules. The sequencer to be tested is placed on the test shelf and the connector cables are connected between the sequencer and the test set. The sequencer is checked for continuity by means of impedance measurements and/or a signal return (+28 VDC) which turns on proper lamps and verifies proper wiring between the module and sequencer connector plugs. The sequencer is also checked for proper values of isolation resistance.

The test set supplies all power required by the S-IVB Sequencer, 1A65666-1, during test: +28 VDC $\pm$ 1 VDC both for relay operation and lamp illumination. The test set connects to the sequencer unit by means of connector cables. The test set provides a pulse signal +28 VDC $\pm$ 1 VDC at 25 ms $\pm$ 5 ms for purpose of relay excitation in special cases.

Continuity tests are performed by means of impedance measurements and lamp indication on the test set lamp test panel. Measurements required are:

a. Resistance

1. 1 ohm
2. 100 megohms
3. 10 K $\pm$ 1 K ohms

b. Current

1. 18 ma
2. 128 ma

The FM/DDAS relay assembly is composed of relays, isolation resistors, and arc suppression circuits. The tests involve continuity via impedance measurements, and a signal return (+28 VDC) for lamp illumination. The test set supplies all power required by the FM/DDAS relay assembly during test, +28 VDC ± 1 VDC. The test set connects to the relay assembly by means of connector cables. The continuity test is performed by means of impedance measurements and lamp indication on the test set panel.

5. <u>DSV-IVB-110 - TEST SET, ELECTRICAL COMPONENT, POWER SYSTEM</u>

The power system component test set is capable of checking the inverter-converter. The test set measures the inverter-converter outputs for changes in line, load, and temperature; and provide means for determining conversion efficiency and harmonic distortion. The test set simulates changes in the line and load and supplies the voltage source (battery simulator) to the inverter-converter and monitors the voltage and current of each inverter output under the specified loading. The test set also measures frequency, power factor, and phase difference, where applicable. The test set is contained within a single bay rack. All meters and controls are located on the front surface of the cabinet; with the exception of a running time meter. The lower section of the cabinet provides a storage drawer to accept the inverter-converter. The drawer contains a running time meter and inverter-converter connecting cables. All external power enters the test set from the rear. The battery simulated output voltage is capable of adjustment between the specified limits of line change. This output voltage is supplied to the inverter-converter for input power, and a lesser voltage is applied to the heat sensing elements (thermistors). Test circuits are supplied within the test set for checkout of the thermistors and other telemetry outputs. The test set contains resistive loads for all outputs requiring them, and a variable reactance load for the 115 volts AC, 400 cps. The circuit of the reactive load contains in addition a frequency and a power factor meter. The voltage across and the current through these loads are displayed by meters. In addition, the phase difference between the sine wave and square wave output is sensed and visually indicated by meter. The test set is capable of monitoring the oscillator supply voltage simultaneously with the frequency (400 cps) delivered from the oscillator. Provision is made for external monitoring of the 115 volt, 400 cps output, the square wave, and all test points. An adjustable DC power source is used to apply voltage across the inverter-converter. The required loads are included across each output. Included in the respective load circuits, are an AC and a DC ammeter. A voltmeter is capable of switching across any output to determine its voltage. The telemetry test circuits have fixed loads and the above mentioned voltmeter is applied across them. Conversion efficiency is determined from input and output power calculations. The facility input will be 115 volts AC ± 10% at 50-66 cycles per second. This is supplied to the differential voltmeter as well as the DC power supply. A variable, regulated power supply is necessary to supply the inverter-converter, thermistors, and phase measuring network. The supply meets the following specification:

a.	Input:	115 VAC ± 10%, 50-66 cps
b.	Outputs:	0-36 VDC, 0-10 amperes
c.	Voltage regulation:	.05%, line and load
d.	Current regulation:	0.2%, line and load
e.	DC ON/OFF switch	
f.	Physical:	Input-output connections on rear Rack mount Minimum height

The controls of the power supply and the AC/DC voltmeter are self contained within these units. The remainder of the front panel requires the following controls:

a. AC power on ON/OFF switch
b. DC console power ON/OFF switch
c. DC inverter/converter power ON/OFF switch
d. Reactive/resistive load switch for 115 VAC
e. Load/no load switch for each output
f. Variable load controls for each output
g. Telemetry test switches
h. Voltage output selector switch
i. Current output selector switch
j. DC ammeter scale selector switch
k. Phase measure circuit calibrator
l. Circuit breaker resets

The AC/DC voltmeter and DC power supply are supplied with meters. The remaining meters are of the 3 1/2 inch diameter, ruggedized, military type with 100 degree scales. The test set includes:

a. AC/DC Differential voltmeter

Range:	0-500 volts
Accuracy:	± .05% DC
	± 0.2% AC
Input:	115 VAC ± 10%, 50-66 cps
DC Polarity switch	
Physical:	Input/output connections from rear
	Rack mount
	Minimum height

b. Power factor meter

Use:	115 VAC, 400 cps reactive load
Scale:	0.3 to 1.0 lagging
Sensitivity:	± .02 pf

c. Frequency meter

Use:	400 cps
Scale:	395-405 cps (expanded)
Sensitivity:	± .25%

d. Ammeter, AC

Use:	115 VAC load current
Scale:	TBD
Sensitivity:	TBD

e. Ammeter, DC

Use:	load currents
Scale:	multiple (TBD)
Sensitivity:	TBD

f. Phase meter

Use:	Indicates phase difference between square wave and sine wave
Scale:	0 to 20 degrees (tentative)
Sensitivity:	± 1 degree

g. Running time meter

Input:	115 VAC, ± 10% 50-66 cps
Scale:	Minimum of 0.1 hours, maximum 10,000 hours
Sensitivity:	± .1 hour

h. Light, Indicator (3 each)

AC input power on, DC console power, DC inverter power

i. Voltmeter, DC

Scale:	24-32 VDC (expanded)
Sensitivity:	± .5%

6. DSV-IVB-112 - TEST SET, PROPELLANT UTILIZATION

The overall goal of the Propellant Utilization Test Set is to checkout and precalibrate the Propellant Utilization Electronics assembly prior to installation in the S-IVB vehicle. Basically this is accomplished by simulating the empty and full capacitance of the LO_2 and LH_2 tank probes and adjusting the Propellant Utilization Electronics assembly for proper outputs monitored by various test equipment of the test set.

The final calibration of the Propellant Utilization Electronics assembly is performed after installation in the S-IVB vehicle using the actual tank probes for the empty capacitance value and adding a value of capacitance in parallel with the tank probes to simulate full capacitance value. All values of input bridge capacitance, referred to herein, as percent of full tank values, will represent the amounts of capacitance necessary to simulate the indicated percentages of propellant mass. Percentage levels will represent the indicated percentages of propellant mass. All capacitance accuracies (including bridge linearities) stated herein as percentages will represent percentages of total change from empty to full tank unless otherwise stated. The Propellant Utilization Test Set is a 3-bay unit. Power required is 115 VAC ± 10%, 60 cps ± 5%, 3,000 VA, and single phase. Inputs to the Propellant Utilization Electronics assembly are as follows:

a. 115 VAC ± 3%, 400 cps ± 1%
b. 100 VDC ± 2 VDC
c. 5 VDC ± 1%
d. ± 1 VDC ± 1%
e. 2 volt ± 1% p-p square wave in phase ± 20° with the 115 V, 400 cps
f. 28 VDC ± 2 VDC
g. Capacitance probe simulators
h. Input signals to test relays and automatic checkout relays

The control panels and measuring equipment are as follows:

a. Oscilloscope - to measure the phase shift between the reference voltage and the output of the valve position amplifier and general testing.

b. Voltage divider - provides very accurate voltage ratios for comparison to various Propellant Utilization Electronics assembly outputs.

c. Recorder - to record the summing point error signal, the LOX and fuel motor control voltages, value command outputs, and the output of the coarse and fine loading potentiometers.

d. Capacitance measuring system - to calibrate the capacitance probe simulators to an accuracy of $\pm$ .01%.

e. AC/DC differential voltmeter - for very accurate voltage measurements of the various outputs of the Propellant Utilization Electronics assembly.

f. Variable capacitors -

   1. Mass sensor - simulates the empty, 20%, 40%, 60%, 80%, and full points of the tank probes.
   2. Step input - used to introduce small capacitance changes into the channel under test.
   3. Velocity input - a motor driven capacitor which varies from the empty to full capacitance value at the rate of 14 pf per minute.

g. Control panel - for routing the various outputs of the Propellant Utilization Electronics assembly to the applicable measuring equipment.

7. DSV-IVB-113 - DESTRUCT/RECEIVER CONTROLLER COMPONENT TEST SET

The DSV-IVB-113 is a manually operated test set consisting of an R.F. signal generator and coder, counter, power supply, voltmeters, and control panels, all of which are rack mounted in a single cabinet.

It is used to bench test the following items prior to installation in the flight vehicle:

a. AN/DRW-13 - Command Destruct Receiver
b. PP2248/DRW-13 - Voltage Regulator
c. EBW Destruct System Controller

The following tests are performed on the Command Destruct Receiver:

a. Sensitivity - reliable subcarrier operation with ± 50 KC deviation and RF signal strength of 5 microvolts or less.
b. Limiter voltage - +0.1 VDC minimum at the signal strength test point with an unmodulated RF signal level of -100 dbm.
c. Overload - no false channel operation shall occur.
d. The decoder assembly relay contact resistance is checked and must be less than 1 ohm.
e. The quitting point is checked.
f. RF bandwidth - at -6 db (650 KC to 800 KC)
   at -60 db (2,800 KC maximum)
g. The RF center frequency must be within ± .01% of specified frequency.
h. Audio output
i. Threshold deviation
j. Decoder bandwidth

The following tests are performed on the voltage regulator with +24, +28, and +34 VDC inputs.

a. regulated +18 VDC
b. unregulated +18 VDC
c. unregulated -18 VDC
d. regulated +6.0 VDC
e. unregulated +28 VDC

The following tests are performed on the EBW Destruct System Controller:

a. Proper logic operation
b. Proper T/M talkback operation

8. DSV-IVB-114 - EBW FIRING UNIT COMPONENT TEST SET

The purpose of the EBW Firing Unit Test Set is to functionally check the EBW Firing units prior to installation in the vehicle. The test set is entirely manual. The following tests are performed on the EBW Firing Unit:

a. Measurement of the monitor line resistor
b. Verification of good filter capacitors
c. Peak and average input current
d. Peak and average trigger current
e. Time from trigger to output
f. Average monitor line voltage
g. Monitor voltage ripple
h. Storage capacitor use time and decay time
i. 8 VDC NO-FIRE
j. 50 V, 10 microseconds, NO-FIRE
k. Output pulse waveshape

The test set is housed in an AMCO rack and contains the following equipment:

a. Oscilloscope
b. Storage drawer for oscilloscope camera
c. Storage drawer for cables
d. Control and monitor drawer which contains meters, logic circuits, and power supplies.

9. DSV-IVB-115 - TEST SET, TELEMETRY COMPONENT PCM/FM

The PCM/FM Telemetry Component Test Set is capable of performing all of the tests required for complete evaluation, adjustment, and fault isolation of the Digital Data Acquisition assembly. The criteria for the design of the PCM test set is to provide the test capability for an end-to-end test and to further provide test capability for fault isolation. The test set is capable of fault isolation to a functional block of the Digital Data Acquisition assembly, such as the A/D converter, the various counters, format generators, and registers. The functions of PCM/FM Telemetry Component Test Set is to evaluate the performance of the Digital Data Acquisition assembly, to detect malfunctions, and to isolate the faults. The test set applies the operating voltages and stimuli, and monitors the response on the outputs. The PCM/FM Telemetry Component Test Set is contained in a 3-bay console, 2 desk top bays and a center bay with a shelf on the front, 30" above the floor. The PCM/FM Telemetry Component test set is manual in operation. The stimuli generators, indicators, and monitors are selected by patch boards and switching networks. The data words in the serial PCM data train are selected by proper programming of the patch board on the data control unit. The frame synchronization pulse and subframe synchronization pulses are also selected by programming the patchboard on the data control unit. The complete data word, frame synchronization word, and subframe synchronization word are available on the outputs from the data control unit. The various stimuli generators are patched or switched to the inputs as required. The monitors and indicators are patched to the various points in the DDA assembly to measure and observe the various outputs and functions.

The stimuli and monitoring requirements for the PCM/FM Telemetry Component Test Set are as outlined below:

a. A serial PAM RZ pulse train with the following characteristics is required as one of the input signal sources.

1. Amplitude of each pulse proportional to channel signal amplitudes.
2. Commutation rate of 7,200 channels per second.
3. Channels per frame - 30 including synchronization period.
4. PAM Duty Cycle - must be capable of being set to 50% ± 5%.
5. Frame and master frame synchronization must be capable of generating a synchronization pattern in accordance with figure 3 and 4.
6. PAM reference level - continuously variable from 5% to 30% of full scale.
7. PAM frame synchronization width - 2 or 3 channel periods selectable.
8. PAM frame synchronization amplitude continuously variable from 0% to 125% of full scale.
9. Data channel amplitudes - all channels capable of being switched to PAM amplitudes of 0, 20, 40, 60, 80, 100, and 125% of full scale.
10. Special information amplitudes - any channel may be set to 100% of full scale or may be continuously adjusted to 0% of full scale independent of all other channels.
11. Missing channels - must have provision for the generation of missing channels, 5 consecutive channels or any 5 random channels.
12. Information accuracy - selected information must be accurate to 0.15% of full scale.
13. Output linearity - linearity for incremental data changes shall be within 0.10% of full scale referred to best straight line.
14. Output stability - no worse than 0.15% for an 8 hour period after a 30 minute warm-up.

15. Interchannel modulation - less than 0.05% of full scale.
16. Pulse rise and fall time - 10 usec. maximum.
17. Channel rate jitter - less than 0.1% peak-to-peak of full channel period.
18. PAM output amplitude - single ended adjustable 0-6.25 volts peak-to-peak. Double ended 0-12.5 volts peak-to-peak.
19. Output impedance - less than 2 K.
20. Output noise - less than 0.05% of full scale
21. Must have provisions for both noise and jitter injection into signal channels.
22. Outputs - all significant waveforms must be brought out to a test point.
23. The serial pulse train must be synchronized or slaved to the master clock in the DDA assembly and must be capable of holding the input to the DDAS at zero (0) level during the frame and master frame intervals.

b. A linear ramp function is required as a stimuli. It is used to check the dynamic linearity of the commutators and the DDA assembly. The ramp function shall have the requirements as outlined below:

1. Ramp time - 0.8 - 100,000 usec
2. Ramp linearity - 0.1% of full scale
3. Time jitter - no greater than .006%
4. Trigger level required - must trigger on any amplitude between 5 and 60 volts peak-to-peak
5. Outputs - + 10 volt gate
   + 5 to + 12 volt ramp
6. Accuracy - ± 0.1% of full scale
7. Linearity of ramp - ± 0.1% of full scale

c. A pulse generator is required for use as a clock source for checking the commutators and for trouble shooting the commutators and DDA assembly. It is also used as a variable rate clock source for marginally checking the DDA assembly. The pulse generator has the following minimum performance requirements:

1. Repetition rate: 2 cps to 2 megacycles per second continuously variable.
2. Must be capable of being triggered from an external source.
3. Delay: 0.0 usec to 10,000 usec continuously variable (delay referenced to synchronization pulse out).
4. Width: 0.05 usec - 10,000 usec continuously variable (width measured at 50% amplitude points).
5. Amplitude: 50 volts into 50 ohm load.
6. Duty ratio: 30% of full amplitude no less than 65% at 20 volts into load.
7. Attenuation: 0-60 db continuously variable.
8. Rise and fall time: .015 usec or less; can be degraded to 1.0 usec both rise and fall time.
9. Polarity: positive or negative (selectable from front panel).
10. Overshoot and undershoot: 5% maximum at full output.
11. Droop: No worse than 15% at a pulse width of 1,000 usec

    Synchronization pulse: Minimum amplitude 10 volts
    Minimum width 0.05 usec
    Rise time 0.03 usec

d. A precision voltage divider is used to set up accurately known voltages for checking static encoding accuracy on the A/D converter and the transfer accuracies of the commutators. It also is used for setting up accurately known voltage levels for checking the static linearity of both the commutators and the A/D converter. The precision voltage divider has as a minimum the following performance requirements:

1. Input resistance: 10 K
2. Number of decades: 6
3. Resolution: 1 PPM
4. Terminal linearity: $\pm$ 5 PPM direct reading correctable by certification to $\pm$ 3 PPM
5. Input power: 5 watts nominal

e. An oscilloscope is required to provide facilities for waveform analysis and measuring time relations and delays. It is used for measuring rise time, fall time, pulse width, and all the general characteristics of the various data pulses and synchronizing pulses throughout both the DDA assembly and the commutators. It is used as an amplitude comparator in the static linearity tests performed on the DDA assembly and the commutators. By using the appropriate plug-in modules, it is capable of making differential measurements of pulse amplitudes and of measuring time relations between various synchronization pulses in the DDA assembly and the commutators. It has the minimum performance requirements outlined below:

1. Sweep Generator:

   (a) Sweep time from 0.1 usec per cm to 5 sec./cm. continuously variable.
   (b) Sweep magnification - 10x
   (c) Sweep accuracy - $\pm$ 3%; with magnifier in $\pm$ 5%.
   (d) Triggering - internal, AC coupled, power line, external AC or DC.
   (e) Trigger sensitivity - internal approximately 2 mm vertical deflection at 1 megacycles, 2 cm at 50 megacycles, external; approximately 0.25 volts p-p at 1 megacycles, approximately 0.5 volts p-p at 50 megacycles.
   (f) Triggering point - control selection of level and slope.

2. Triggering Point:

   (a) Bandwidth - DC coupled, DC - 500 kilocycles; AC coupled, 2 cps to 500 kilocycles.

(b) Sensitivity - 2 ranges; 0.1 volt/cm and 1.0 volt/cm

3. Main Vertical Amplifier:

(a) Rise time: less than 7 nsec

4. Calibrator:

(a) 1 kilocycles square wave
(b) Voltage - 2 ranges 1 volt p-p and 10 volt p-p

5. Cathode Ray Tube:

(a) Type P31 aluminized phosphor
(b) Post accelerator with a minimum of 12 kilovolt accelerating potential.

6. Beam Finder:

7. Intensity Modulation for trace:

8. Vertical Plug-in Amplifier:

(a) Mode of operation: channel A only, channel B only, channels A and B on alternate sweeps, channels A and B chopped, channel A minus channel B (differential input).
(b) Sensitivity: .05V/cm to 20 V/cm continuously variable
(c) Attenuator accuracy: $\pm$ 3%
(d) Bandwidth: DC coupled, DC - 50 megacycles, AC coupled; 2 cps - 40 megacycles
(e) Rise time: less than 9 nsec
(f) Vertical position range: $\pm$ 9 cm
(g) Input impedance: 1 meg, shunted by no more than 30 pf
(h) Polarity of presentation: (+) up or (-) down selectable
(i) Common mode rejection: (differential input) At least 40 db at maximum sensitivity or 30 db when using attenuators at frequencies to 1 megacycles.

9. Sweep Delay Plug-in:

The sweep delay plug-in is used in making the pulse to pulse time measurements, the time jitter measurements, and also allows mixed presentation of high speed and low speed pulse trains simultaneously.

(a)	Delay time:	1 usec. to 10 sec.
(b)	Delaying sweep:	2 usec/cm to 1 sec/cm.
(c)	Delay length:	0-10 cm.
(d)	Accuracy:	$\pm$ 1% 2 usec. to 0.1 sec. range, $\pm$ 3% 0.2, 0.5, and 1.0 sec. range
(e)	Delay function:	Trigger main sweep, arm main sweep
(f)	Triggering:	Internal; AC coupled 2 mm or more vertical deflection, power line, or external AC or DC coupled 0.5 V p-p
(g)	Sweep selector:	(1) main sweep (2) delaying sweep (3) main sweep delayed (4) mixed sweep
(h)	Delayed trigger out:	Approximately 20 V positive

f. An AC/DC differential VTVM is required for monitoring the DC stimuli levels that are applied to the Unit-Under-Test and for monitoring and setting the various power supply levels to the Unit-Under-Test. It also is used for measuring the various circuit levels when a malfunction occurs and fault isolation is to be performed. The AC/DC differential VTVM has the following minimum performance requirements.

1.	DC voltage range	0.5 volts - 500 VDC
2.	AC voltage range	0.005 - 500 VAC
3.	Input impedance (at null)	AC - 1 meg shunted with 25 pf DC - infinite
4.	Resolution	50 microvolts from 0.5 volts to 5.0 volts, 500 microvolts from 5.0 to 50 volts, 5 microvolts from 50.0 volts to 500 volts

5. Accuracy: DC - $\pm$ .05% of input from 0.1 to 500 volts; $\pm$ .1% of input or 50 microvolts whichever is the greater from 0.0 to 0.1 volts

6. Direct in-line readout

7. Automatic decimal point

8. Reference stability $\pm$ 0.01% from 105 volts to 135 volts input line $\pm$ 0.01% per hour after a 30 minute warmup.

9. Floating input: + or - can be grounded

g. A 4 digit in-line display unit is required to display the data words generated by the A/D converter. The display unit must accept 10 line parallel data from the digital data control unit and convert it to 4 octal digits for display. This is done by a binary to octal converter and 4 digit in-line readouts. This unit in conjunction with the digital data control unit takes any data word in the format as selected by the digital data control unit and displays this selected data word in 4 octal digits.

h. A digital data control unit is required to check the data format, to separate out the various synchronization pulses, and to separate and provide on output lines, the selected data word out of the master frame. The frame and master frame synchronization indication are shown on the "in synchronization lights" on the front panel of the digital data control unit. The synchronization words format to be recovered is set up on the patch board of the digital data control unit. By using the digital data control unit, the following parameters of the DDA assembly can be checked; the data format, synchronization words format, system synchronization stability, proper sampling reference of analog inputs, proper formating of the discretes input, encoding accuracy, and linearity of the analog to digital conversion. The digital data control unit has the following minimum performance characteristics:

1. Word length adjustable from 2 - 33 bits
2. Frame length of 1 - 300 words
3. Master frame of from 1 - 600 words
4. Synchronization patterns

   (a) Frame up to 33 bits with any combination of 1's and 0's.
   (b) Counter outputs - The binary outputs from the master frame length counter and frame length counter shall be available.
   (c) Synchronization pulse - Master frame and frame synchronization pulses shall be provided.
   (d) Patchboard - The patchboard shall permit programming the data control unit for the input format. Word length, master frame length, master frame synchronization, frame length, and frame synchronization times shall be programmable. Each programmable area on the patchboard shall be an amp type patchboard

10. DSV-IVB-252 - FM TRANSMITTER TEST SET

The FM Transmitter test set is used to check the FM transmitters for proper operation, both dynamic and static, and to isolate malfunctions down to a part or group of parts. The test set provides the necessary operating voltages, input signals, and output monitoring.

The transmitter test set consists of 2 racks of equipment and the necessary plugs and receptacles. Test set dimensions shall be: depth, 25 1/2 inches; width 42 1/8 inches; and height, 77 1/2 inches. A smooth writing surface shall be attached at desk height to the front of the console. The transmitter test set provides input signals and output monitoring to check the FM transmitters for proper operation. The test equipment shall be manually operated and capable of isolating malfunctions to a part or group of parts. It shall be independent of all other equipment in operation.

The tester is capable of the following functions:

a. Providing the necessary operating voltages.
b. Providing the required input stimuli
c. Measuring the output power
d. Recovering the modulating waveforms
e. Measuring static and dynamic deviation
f. Determining overall transmitter efficiency

The test set is capable of providing AC, DC, and pulsed inputs to the transmitter and displaying visually both the input and the demodulated output waveforms. The transmitter under test and a dummy load is mounted in an RF shielded drawer to prevent unwanted radiation. The test set is capable of supplying 0-36 volts, 10 amperes DC power from each of two separate sources. Dynamic regulation shall be .01% or better and ripple shall not exceed 1 millivolt rms. The test set is capable of supplying 3 types of input signals to the transmitter under test.

a. A DC signal of 0-1,000 volts
b. An AC signal of 250 cps to 100 KC frequency
c. A pulsed signal of 20 cps to 2 mc repetition rate.

The test set measures RF power up to 60 watts in the range of 215 to 265 mc with an accuracy of 5%. A transmitter dummy load capable of dissipating up to 90 watts of power is provided. The load is completely shielded and non-radiating. It is mounted within the transmitter test drawer. The test set is equipped with a digital type frequency meter capable of measuring frequencies up to 510 mc. A deviation meter is provided for operation in the 215 to 265 mc range. It is capable of deviation measurements up to 150 KC deviation with an accuracy of 3%. In addition, a demodulated output is provided. A voltmeter is provided capable of measuring both AC and DC voltages up to 500 volts with an accuracy of .05% for DC and .2% for AC measurements. The test set has an oscilloscope capable of displaying both input and output waveforms simultaneously.

DESCRIPTION OF EACH OF THE ITEMS TO BE TESTED

1. VOLTAGE CONTROLLED SUBCARRIER OSCILLATORS

The VCO is a solid state unit which is designed to accept amplitude modulated information over a wide frequency, with frequency deviation around the standard Inter Range Instrumentation Group (IRIG) sub-carrier frequencies. The mixed output signals from a group of sub-carrier oscillators will be of sufficient level to drive a wideband amplifier.

2. SLOW SPEED MULTIPLEXER UNIT

The slow speed multiplexer unit is an encoded time commutator unit for vibration data.

Inputs:

a. 5 VDC reference
b. 0 to 5 VDC input on 2 or 4 lines per channel
c. 24 to 32 VDC power

Outputs:

a. 5 volt pedestal .1 to .3 seconds wide
b. Output line and input data are on 2.5 volt pedestals

3. CENTRAL CALIBRATION ASSEMBLY

This unit is used in conjunction with the FM/FM telemetry. It functions as a calibration control and a reference signal source for subcarrier oscillator units. The unit provides up to 6 outputs to energize the calibration relays in each subcarrier oscillator unit at the appropriate time and applies a 0 to 100% sequence of calibration steps to each subcarrier oscillator unit.

Inputs:

a. Calibration commands 28 VDC
b. Inflight/preflight commands 28 VDC, 5 VDC reference

Calibration Clamp Levels:

a. 0 to 10 VDC
b. 24 to 32 VDC output
c. 28 VDC or 0 VDC, on time 700 KC (6 lines)
d. Calibration buss 1.25, 3.5, 3.75, 5.00 VDC
e. Level duration 140 milliseconds, 6 times per command

4. CENTRAL CALIBRATION COMMAND DECODER ASSEMBLY

The Central Decoder assembly will be capable of accepting 12 calibration command signal lines. The signal lines shall be parallel digital coded in 3 groups to identify 27 racks, 20 channels, and 3 modes of operation. Six binary coded signal lines shall identify the racks and 2 the modes of operation. Three binary coded and 1 trinary coded lines shall identify the channels. Signal input voltages shall be zero, +8 volts, and +27 volts; representing binary (trinary) 0, trinary 1/2, and binary (trinary) 1, respectively.

The Central Decoder assembly will decode the rack and mode input command signals and generate the required output command signals. The assembly shall function as a distribution point for the channel command signals.

The Central Decoder assembly will provide 32 output command signal lines. These will consist of 4 channel, 1 mode, and 27 rack command signal lines. The rack lines shall be binary coded and each line shall identify 1 of 27 racks. The output signal levels on the rack lines shall be +22 volts for an unselected rack and zero volts for a selected rack. The mode line shall be trinary coded, with each state identifying 1 of 3 modes of operation. The output signal levels for the mode line shall be zero volts for the run mode, +8 volts for the low mode, and +15 volts for the high mode.

5. CENTRAL CALIBRATION COMMAND CHANNEL DECODER ASSEMBLY

The Channel Decoder assembly will be capable of accepting 6 calibration command signal lines. These lines will be used to identify 1 rack, 20 channels, and 3 modes of operation. A single line will identify the rack with which the Channel Decoder assembly is associated. The assembly will obey the channel and mode command signals only if a rack command signal is present. One trinary coded and 3 binary coded signal lines will be used to identify the 20 channels. The remaining signal line will be trinary coded and will be used to identify the 3 modes of operation. Signal levels will be as follows:

a. Rack Selector

Logic 0	+22 volts
Logic 1	zero volts

b. Channel Selector

Logic 0	zero volts
Logic 1/2	+8 volts
Logic 1	+27 volts

c. Mode Selector

Logic 0	zero volts
Logic 1/2	+8 volts
Logic 1	+15 volts

The Channel Decoder assembly will decode the input command signals and, if selected, will provide the proper output signals.

The Channel Decoder assembly will have 40 output signal lines, 2 corresponding to each of the 20 channels. One of the 2 signal lines will be used to command its associated channel into the low calibrate mode. The other line will be used to command the channel into the high calibrate mode. The absence of both the low and the high calibrate mode signals will command the channel into the run mode of operation. The output signal from the assembly, on a given channel, will remain until that channel is commanded into another mode of operation.

6. SINGLE SIDEBAND - FM TRANSLATOR ASSEMBLY

The SS-FM Telemetry System was developed especially for vibration telemetry. The basic system is extremely efficient, in terms of spectrum utilization, as it provides 15 independent data channels, each with a frequency response of 50-3,000 cps, in a total bandwidth (BW) of only 76 KC. This represents a usable data capacity approximately 10 times that of FM-FM within the same BW. SS-FM is a frequency sharing telemetry system in which many individual data channels are converted to a single sideband subcarrier, each of a different frequency. These are combined for transmission by frequency modulation over an r-f link. The SS-FM Translator assembly is inherently a modular system, consisting of single amplifiers, modulators and filters, which are identical in each channel. The system employs solid state devices exclusively; hence, power consumption and heat dissipation are low. The application of mechanical filtering techniques and the development of special filters have made this a practical system. The input and output parameters are as follows:

a. The input power is 28 volts +2, -4 volts
b. Transient overvoltage (Signal data input characteristics):

   1. The data inputs consist of 15 channels plus 1 special service channel. Channels 1 through 15 have 50 to 3,000 cps response. The special service channel has 20 to 1,200 cps response.
   2. The amplitude stability is stable with reference to the pilot tone within 1 db over worse combination of specified environments.
   3. The input level change produces a corresponding change of output within .25 db.
   4. Channel ripple caused by upper sideband mechanical filters does not exceed 1.0 db at +25 ± 3° C.
   5. The individual channel input impedance is 100 K ohms ± 3% at 1,500 cycles in either power ON or OFF position.

6. The input signal level is 5 ± 10% volts peak-to-peak for a full scale modulation.

7. The composite signal output level is adjustable between .15 and 3.0 volts peak-to-peak where all channels are loaded to 50% of full scale with non-coherent noise sources, 20 to 3,000 cps.

c. Hardline Output Isolation Amplifier

1. The hardline output isolation amplifier accepts as its input signal a composite output signal at levels specified in the composite signal output requirements.

2. The input impedance shall be 100 K ohms minimum for 50 cps to 100 KC.

3. The frequency response is not less than the frequency response of the second summing amplifier of the unit.

4. A change in gain will not exceed ± 0.5 db for specified changes in the unit supply voltage and temperatures.

5. At any gain setting, distortion is less than 1% at maximum rated output. The output voltage is adjustable to 2 volts rms into a 130 ohm balanced line at an input level as specified.

6. A load or no-load condition, including short circuiting, does not cause more than ± 1 db change in composite output to the FM transmitter.

7. The output impedance of the composite signal is 4,000 ohms maximum at 1,500 cps.

8. Individual carrier channel suppression is 30 db minimum.

d. The main carrier oscillator frequency is crystal controlled at 910.025 KC ± .0012% and maintains this stability under all operating conditions.

e. Reference Channel

1. A reference channel is provided as an amplitude and frequency reference for the system. The reference

frequency is 1/12 of the crystal frequency and is summed with the signal inputs to provide amplitude reference. A change in pilot tone amplitude with respect to the channel output levels with constant input levels will be no more than 1 db. The pilot frequency shall be stable, within $\pm$ 5 cycles over the specified environment.

f. The comb filter required for selection of the second carrier frequency is a ceramic type.

g. The channel to channel cross talk and distortion in any 1 channel as measured with the frequency selective voltmeter at the output of the summing amplifier shall be at least 40 db below full scale output when the remaining channels are loaded to 50% of full scale output.

h. The AGC shall hold the output to within $\pm$ 1 db of nominal output level with an input signal level change of 20 db. The AGC attack time shall be 6 milliseconds nominal and recovery time 8 milliseconds nominal.

i. Calibration input and control circuitry is provided for each data channel with the exception of the special service channel.

j. Data Source Faults

    1. The units will be protected from voltage surges over 5 volt peak-to-peak input voltages.
    2. Input voltage surges will not cause loss of data on other channels.
    3. Recovery from input voltage surges to normal operation will be within a minimum of 5 seconds upon removal of input surge voltage.

k. The back current measured at the individual channel input terminals shall not exceed 5 microamperes peak AC and DC.

l. The special service channel frequency shall be 20 cps to 1.20 KC.

7. INVERTER/CONVERTER

The inverter/converter provides 400 cps power to the Propellant Utilization Electronics assembly as well as a calibration signal to the Single Sideband Translator assembly. The input power is 28 VDC at 4 amperes. The outputs are as follows.

a. 115 volts AC ± 5%, 400 cps ± 1%, sine wave
b. 1 volt sine wave ± 5%, 400 cps ± 1%
c. 2 1/2 volt p-p square wave
d. 117 volts DC ± 2%
e. 21 1/2 volts DC ± 2%
f. 42.2 volts DC ± 2%
g. 5 volts DC ± 1%

8. PROPELLANT UTILIZATION ELECTRONICS ASSEMBLY

The function of the Propellant Utilization system is to (1) regulate the flow of oxidizer to the engine to insure a minimum residual at burnout, (2) supply signals for accurate fuel and oxidizer loading, and (3) provide ground and in-flight indications for propellant mass determination.

The Propellant Utilization system consists of the following sub-assemblies:

a. Sensor Assembly, Oxidizer mass
b. Sensor Assembly, Fuel mass
c. Electronics Assembly, Propellant Utilization
d. Valve Positioner Assembly

The mass sensors each form 1 leg of a self-balancing comparison bridge. Variation in propellant masses, such as a variation caused by consumption of propellants during flight, could cause proportional capacitance changes which momentarily unbalance the servo-bridges. The unbalance signals feed amplifier-quadrature rejection circuits that amplify and condition the signals to drive AC servo-motors.

The motors, in turn, position ganged potentiometers which produce feedback signals to rebalance the bridges as well as signals for loading or in-flight telemetry of propellant masses. The outputs of other portions of these ganged potentiometers are subtracted to form a signal which reflects the deviations from the nominal oxidizer-to-fuel-mass ratio. This error signal is shaped to attenuate the effects of propellant slosh and amplified to a magnitude sufficient to drive an AC servomotor for positioning the engine mixture ratio control valve. This motor also positions a 2-ganged potentiometer for control feedback and telemetry. The inputs to the P.U. electronics assembly are as follows:

a. 115 volts AC, 400 cycles $\pm$ 1%
b. 100 volts $\pm$ 2 volts DC
c. 5 volts $\pm$ 1% DC
d. + 1 volt $\pm$ 1% DC
e. 2 volts $\pm$ 1% peak-to-peak square wave (In phase within $\pm$ 20° with the 115 volts AC, 400 cycle power source)
f. 28 volts $\pm$ 2 volts DC
g. Capacitance change (probe simulator)
h. Input signals to test delays in the relays

9. PCM/DDA ASSEMBLY

The Digital Data Acquisition Assembly shall be capable of accepting 100 channels of parallel digital data and 5 channels of DC or synchronized pulse amplitude modulated data, 2 channels of which are 180° out of phase with respect to the other 3. The assembly shall multiplex and convert the 3 in-phase signals and 1 of the out-of-phase signals into a series of 10-bit parallel digital words. An external command shall select the out-of-phase data signal to be accepted by the assembly. The assembly shall multiplex the converted analog signals with the digital input signals and place the resulting signals into the proper data format. Two synchronization words of 30 bits each shall be generated within the assembly and inserted periodically into the data train to establish the format.

The Digital Data Acquisition Assembly shall perform the following functions:

a. Programming

The assembly shall contain a crystal controlled clock and the logic necessary to generate all gating and timing pulse rates required by the assembly itself, and by the multiplexer assemblies used in conjunction with it. The basic clock rate shall be 288,000 pps. The programming logic shall enable the Analog-to-Digital Converter, but the conversion shall take place asynchronously with the Programmer at a clock rate of 250,000 pps.

b. PAM Multiplexing

The assembly shall contain a set of programmed switches which time share 4 of the 5 PAM signal lines and present the composite PAM signal to the Analog-to-Digital Converter.

The signals presented to the switches shall be PAM pulse trains, each at the rate of 3,600 samples per second (s/s), and each having a duty cycle of 50%. The pulse trains shall be synchronized with one another and with the Digital Data Acquisition Assembly. The timing shall be such that 2 of the input signals are 180° out of phase with respect to the other 3.

The programmed switches shall be gated in such a manner that each of the 3 in-phase signal lines is sampled one-third of the time and the selected out-of-phase signal line is sampled one-half of the time. It shall be possible to sample either of the out-of-phase signal lines upon the application of an external mode command signal. The output of the programmed switches shall be a PAM wave train at a rate of 7,200 s/s and having a duty cycle of 100%.

c. Analog to Digital Conversion

The assembly shall contain an Analog-to-Digital Converter (ADC) which accepts the sampled analog input at a rate of 7,200 s/s and converts it to a series of parallel digital words at the same word rate. The conversion process shall take place upon command of the programmer. Commands shall recur at a rate of 7,200 pps and shall be synchronized with the programmed switches. These commands shall enable the clock in the ADC. The conversion process shall then take place asynchronously with the programmer at a rate of 250,000 pps. The ADC shall operate on the half-split principle (successive approximation), with the conversion taking a maximum of 60 microseconds. At the end of this time the ADC clock shall be disabled. It shall remain disabled until the next command from the programmer. During this period the digital equivalent of the analog sample shall be available at the ADC output in parallel digital form.

d. Digital Buffers and Registers

The assembly shall contain buffers and registers capable of accepting 100 channels of bi-level or parallel digital data. The buffers shall process the data in 10 groups of 10 channels each; each group being the equivalent of 1 ADC output word. Groups shall be processed in either of 2 ways. Some groups shall be buffered and shifted into magnetic core registers (MCR's) upon command of the programmer. A "Program Patch" shall make it possible to shift the data groups into the MCR's in a programmable manner.

The MCR's shall provide DC isolation of the data sources and temporary storage of the data. The data shall be read from temporary storage upon command of the programmer. The program patch shall permit the groups to be inserted into the format in a programmable manner, and shall thus establish the sampling rate for each bi-level group.

Other bi-level groups shall be buffered and read directly into the format with no DC isolation or temporary storage. The program patch shall again permit the groups to be inserted into the format in a programmable manner.

e. Frame Identification

A unique 30-bit code word shall be generated within the assembly to provide a means of synchronizing external equipment with the PCM output. This word is the "Sub-Frame" synchronization word. It shall be available to the format logic in parallel digital form as three groups of 10 bits each; each group being the equivalent of 1 ADC output word. The 3 groups shall be inserted as the final 3 words of each sub-frame. Provision shall be made for complementing the sub-frame synchronization word corresponding to every thirtieth sub-frame. The 30-bit word thus generated is the "Major-Frame" synchronization word and serves to mark the end of the major-frame.

Provision shall be made for programming the sub-frame synchronization word so that any desired 30-bit code word and its complement may be used for synchronization.

f. Digital Multiplexing and Formating

The assembly shall contain the logic required to time multiplex the paralleled digital outputs of the Analog-to-Digital Converter, the digital buffers, the magnetic core registers, and the frame identification logic. The digital multiplexing and formating shall be performed by a parallel storage register (PSR) in conjunction with its associated logic gates. The logic gates shall be connected in such a way that the PSR can accept its input from any one of the signal sources. The programmer shall determine which signal source is to be sampled by the PSR, during any word time, and shall command the logic gates accordingly. The programmer shall thus dictate the word time into which each data source is to be inserted.

The parallel digital word stored in the PSR shall be made available to the serializing logic and to an output connector for use in digital tape recording.

g. Serializing and NRZ Output Logic

Logic shall be provided to convert the sequence of parallel digital words stored in the PSR to a serial digital pulse train having an NRZ (S) format. This pulse train shall modulate a voltage controlled oscillator and shall be buffered and provided on an output connector for use as a modulating input to the PCM/FM transmitter. The output of the voltage controlled oscillator shall be provided on a connector for twinaxial connection to the ground DDAS.

10. FM TRANSMITTER

The FM transmitter consists of a crystal controlled oscillator, multipliers, amplifiers, and modulators which will allow SS/FM, PAM/FM/FM, PCM/FM data transmission.

The FM transmitter is operated from a power source of 24 to 31 volts DC.

The input current required by the FM transmitter is 1.3 amperes or less. The input signal to the transmitter shall be one of the following:

a. A mixed FM signal from a wideband amplifier driven by a group of subcarrier oscillators having center frequencies of 400 cps to 70,000 cps. The level of the mixed signal shall be sufficient to swing the output frequency ± 125 KC.

b. A bit-rate of 72,000 bits per second and a non-return to zero (NRZ) coding. The level shall be sufficient to deviate the transmitter ± 125 KC.

The design of the transmitter is such that the power return is isolated from chassis or case ground. The minimum insulation resistance as measured between power return (-28 volts DC) and the transmitter case shall be 50 megohms at + 50 volts DC.

An input of 1.25 volts, rms amplitude shall cause the transmitter to deviate at least ± 125 KC but less than ± 150 KC under all operating and environmental conditions.

11. COMMAND DESTRUCT RECEIVER AND EBW DESTRUCT SYSTEM CONTROLLER

The EBW destruct system controller contains all the necessary circuits to control 1 set of equipment required for destruction of the Saturn vehicle system. It controls a command destruct receiver, EBW firing unit and necessary signals to the vehicle system for thrust termination. The controller is universally applicable to all stages of the Saturn vehicle and can be adapted for either manned or unmanned, orbital or nonorbital flights.

The command destruct receiver is a 10 channel crystal-controlled FM receiver. The 10 decoder channels are tuned to standard frequencies and internally wired for logic-controlled outputs. The receiver is used to provide a destruct arm command, destruct command, and command destruct receiver cutoff command to the EBW destruct system controller during the flight of the Saturn vehicle.

12. EBW FIRING UNIT

The EBW firing unit is installed in the vehicle and consists of a high voltage power supply, an energy storage unit, and a switch and trigger circuit. The trigger circuit shall operate when stimulated by its associated trigger signal. The input to the EBW firing unit is + 28 VDC. The firing unit shall operate within requirements in 24 to 32 VDC. The voltage on the 1.0 microfarad storage unit is 2,300 $\pm$ 100 VDC. A damped sinusoidal wave is the output.

13. SEQUENCER ASSEMBLY

The sequencer is a switching device capable of turning ON or OFF all loads requiring control after liftoff. These loads are turned ON or OFF as a function of time, ground command, and/or the state of the vehicle as indicated by pressure switches, liquid level sensors, etc. A single version of the sequencer will include the capability of controlling both the S-IB and S-5 missions.

The transmitter is capable of being tuned within ± 4 mc of any specified frequency without requiring factory adjustments or special tools.

The drift of the transmitter unmodulated output frequency shall be less than ± 0.01 per cent for 30 minutes following a 3-minute warm-up period.

The transmitter generated noise shall be equal to or less than ± 3 KC peak-to-peak under all operative and environmental conditions and less than ± 1 KC under an ideal laboratory condition.

The transmitter non-linearity of the output signal frequency swing versus input signal magnitude for any subcarrier frequency shall be less than ± 1 percent of 125 KC from the "best straight line" drawn through the date points. The "best straight line" is defined as that line which minimizes the deviations between it and the actual performance curve.

The modulator frequency response of the transmitter shall be within ± 1.5 db from 30 to 100,000 cps.

The FM transmitter output amplitude modulation shall be less than 5 per cent under all operating and environmental conditions, specified.

The transmitter shall meet the requirements of its specification when operated into a load with a standing wave ratio of 2.5 to 1 or less.

The transmitter shall have an output of 3 watts minimum into the specified load under all operative and environmental conditions specified.

There will be 111 lines available from the switch selector. A pulse will appear on 1 line at a time, on command of a computer in the Instrument Unit. The pulse will have a minimum duration of 20 ms, and will have a magnitude of $28 \, ^{+2}_{-5}$ volts. Pulses can follow each other at a maximum rate of 10 pulses per second, and will deliver a maximum current of 100 ma. The power source for the pulses is the S-IVB main (forward) bus.

There will be 16 inputs to the sequencer from pressure switches, temperature switches, and liquid level sensors. All these sensors are two-state devices that will show either an open circuit or $28 \, ^{+2}_{-4}$ VDC to the sequencer. The current capability of all sensors is at least 100 ma. into an inductive load.

There will be 1 input from each of the 2 range safety systems. These are open circuit or $28 \, ^{+2}_{-4}$ VDC signals, capable of driving a 2 amp. resistive load.

There will be 1 input from the stage below S-IVB. This input will drive an interlock relay to block any engine start signals received before separation.

There will be 2 inputs from the aft umbilical cable, via the aft control distributor, to control the fuel vent valve independently of the flight control path.

Measurement outputs to the Digital Data Acquisition system will be isolated from sequencer circuits by 10 K resistors. Measurements will be made at the following outputs:

a. Engine start
b. Change ullage ignition
c. Fire ullage ignition
d. 1750 pounds ullage
e. 150 pounds ullage

The sequencer will not be packages. The modules will be attached directly to a panel of the vehicle, along with mounting brackets to hold the connectors.

DESCRIPTION OF EACH OF THE AVAILABLE AUTOMATIC TEST EQUIPMENTS

1. NORTRONICS SP-8A

The SP-8A is identical to the Navy's automatic Mark 414 test set which is manufactured by Nortronics and used in the Polaris program. The following features are listed:

a. Self Test - a special punch tape is used to exercise the SP-8A and to verify the operative conditions of its own circuitry.

b. The SP-8A indicates malfunctions of its system by means of front panel function lights.

c. Tape search - an automatic search for component test on a section of the punch tape is provided. In addition, single-frame advance is provided to allow frame-by-frame selection of the test procedure.

d. Ease of Tape Program Changes - test procedure changes can be accomplished on sight by means of a tape preparation unit. All portions of the tape not undergoing changes are reproduced automatically in a matter of minutes.

e. Test Interrupt - on an out of tolerance condition in the equipment under test occurs, the test sequence stops, visual "HI or LO" indication are displayed on the indicator control panel, and an audible alarm is sounded.

f. Manual Override - the operator may actuate the manual override switch which causes the tape reader to proceed to the next test sequence. A test override indication is automatically printed on the output tape, when the operator exercises the override option.

g. Maintenance Consideration - parts are replaceable without interference from, damage to, or removal of adjacent parts. Drawers are mounted on tilt-lock chassis slides and may be serviced from the front of the system. A minimum of disassembly and disconnection is required to remove drawers from the enclosure.

h. Electrical Design Considerations - the logic circuitry is an optimum marriage between solid state and conventional design. Electrical functions are packaged in a mechanically modular fashion.

i. Expandability - the test set capability may be expanded by adding to the stimuli, test points, and measuring functions with a minimum amount of console wiring changes.

j. Manual Control - manual control of the automatic functions are provided. The manual functions are divided as follows:

1. Programmer controller
2. Automatic stimuli and service equipment
3. Manual section

1.1 Program Controller

The programmer-controller controls the tape test program, selects the test points, converts the signal value to digital form, compares this measurement with predetermined tolerances, and prints the measured value. A description of the various drawers in the programmer controller is given below:

a. Comparator - the comparator is used to determine the compliance of the measured value with established high and low limits. This determination is accomplished by complimentary addition of the measured value and the tolerances in binary-decimal form.

b. Indicator and Control - the indicator and control provides the functions of light indication, in line display, and manual control.

c. Indicator - the indicator contains an in-line readout on which the following information is presented.

1. Test sequence number
2. Type of measurement
3. Measured value
4. HI-GO-LO indication
5. WAIT (to indicate a programmed delay)

d. Manual Control - the following manual control functions are provided on the indicator and control panel:

1. Power ON-OFF
2. Manual Automatic - the MANUAL-AUTO switch will determine the method of test set operation.
3. Tape Search - the TAPE SEARCH switch will cause the tape to advance to a preselected point.
4. Manual Override - the MANUAL OVERRIDE switch allows the operator to bypass a NO-GO test and to proceed with the sequence.
5. Measurement Repeat - the MEASUREMENT REPEAT pushbutton will reset the digital multimeter or frequency counter and permit a measurement to be repeated without changing the test parameters.
6. Start - the START switch will initiate the advance of the tape.
7. Stop - the STOP switch will cause the tape to stop.

e. Test Point Selector - the test point selector connects the circuits in the unit under test to specific circuits within the test set to the digital multimeter. Maximum flexibility is provided by allowing any individual test point of two groups of 100 input test points, each to be connected to the digital multimeter.

f. The Digital Multimeter - an analog to digital converter is provided to measure analog functions selected by the test point selector. Ranges are selected by the programmer and timer module for measuring the following functions:

1. DC voltages
2. AC voltages
3. Peak voltage
4. Resistance

g. Frequency Counter - the frequency measuring capability of the frequency counter is in the range of 1 cycle per second to 1 megacycle per second. The input may be either pulsed or alternating. The voltage amplitude of the input is 1 millivolt minimum to 100 volts maximum. Programmed attenuators reduce the input voltage level to that required for the measuring circuitry. The time base generator is a 1 megacycle temperature-stabilized crystal oscillator with a frequency stability of 3 parts in 10^7 per week. This frequency is counted down to obtain the time intervals from 1 microsecond to 1 second. Input amplifiers are provided to allow frequency ratio measurements to be made. The resultant measured frequency is indicated by four digits in decimal form.

h. The Programmer-Timer - the programmer-timer controls both the test set and the unit under test during automatic operation. Information is sequentially introduced into the test set by means of an eight-bit punched tape fed into a tape reader. The tape address and command code is converted into binary and decimal codes which are transmitted to the various drawers for control purposes. Upon receipt of a feedback signal from the drawer being controlled, the programmer advances the program tape to the next frame. The programmer-timer also is capable of establishing and monitoring time delays.

   A cannister containing the punched tape is mounted on the front panel of the programmer and timer drawer. The cannister is capable of handling a 40 foot roll of tape, 1 inch in width, and enables the tape to be fed into the programmer in a continuous loop. The cannister protects the tape from damage during operation, transportation, and storage.

i. Printer - the printer provides a permanent record of test results. As each measurement is completed, the measured value, test number, type of measurement, and indication of compliance or non-compliance with tolerance limits are printed on a 3 inch wide paper tape.

j. Power Distribution - the power distribution drawer distributes ac and dc prime power to the test set and provides overload protection for the prime power source.

k. Primary Power Supply - the primary power supply, with an input of nominal commercial 60 cycle power, is capable of supplying 3 programmable voltages of 24.5 volts dc, 26.5 volts dc, and 28.5 volts dc. Short circuit protection is provided.

l. Regulator AC line voltage - an ac regulator is provided that is capable of supplying the basic ac input power from the primary unregulated 115 volt, 60 cps power input. The ac regulator provides an ac output at 115 volts $\pm$ 0.3% with a variation of input voltage of 103.5 to 126.5 volts ac.

m. Automatic Stimuli - the automatic stimuli consists of a group of items under control of the programmer-controller which supplies necessary stimulation to the unit under test. Stimuli includes a variety of voltages and frequencies. Several conversion devices required for special types of signals are included.

n. Special Circuits - a special circuits drawer provides stimulation of specific functions of the unit under test and circuits necessary for special and seldom used tests. It contains an exclusive "OR gate", an operational amplifier with appropriate attenuators, a multivibrator to stimulate solid-state logic circuitry, a servoamplifier simulator circuit, a hydraulic valve simulator, and a 26.5 volt, 400 cycle inverter.

o. Low Voltage Power Supplies - 1 fixed and 6 programmable low voltage power supplies are provided. The fixed power supply has an output capability of 1 ampere at 12.0 $\pm$ 0.48 volts dc. A maximum of 40.5 volts dc is delivered by the drawer. The programmable power supplies have outputs of 0 to 36 volts dc. Four of these variable power supplies deliver their output in 1 volt increments while the remaining two supplies deliver their outputs in 0.5 volt increments. Voltages of less than 10 volts can be programmed to an accuracy of 1%. Voltages greater than 10 volts can be programmed to an accuracy of 0.5%.

p. AC Signal Generator - an ac signal generator provides frequencies at 2, 10, 80, 100 and 800 cps in several ranges.

q. High Voltage Power Supplies - Two programmable high voltage power supplies provide voltages within the range of 10 to 100 volts dc, in 10 volt increments. An additional supply provides an output within the range of 10 to 109 volts dc, in programmed 1 volt increments. Each of the 3 power supplies delivers 100 milliamperes. The accuracy of the programmed voltages is within $\pm$ 1%.

r. Service Equipment - the following types of equipment are provided as service equipment:

1. The equipment necessary for connecting electrical output signals from the "Unit Under Test" to the SP-8A test set measuring equipment.
2. The electrical loading.
3. The signal conditioning equipment (sensors). Connections of these sensors are accomplished by means of a program board. This board is the interface between the test set and the system to be tested. Stimuli, loads, switching and test points are interconnected on this board by the use of patch cords. When the program board is inserted into the test set and the necessary adaptor cable has been connected to the test specimen, the test "setup" is complete.

s. Connector Panel - a connector panel is provided for the connection between the program board and the "Unit Under Test". In addition, other jacks and connectors are provided for the purpose of using bench type test equipment and stimuli which may be patched in for special tests.

t. Program Board Panel - a program board is used as an electrical interface between the test set and the "Unit Under Test". Interconnection of stimuli and test points for the "Unit Under Test" is a function of the program board. The program board also may contain specialized test circuitry such as semiconductors, resistors, capacitors.

u. Control Relays - control relays are directed by the programmer and time module to apply stimuli to the "Unit Under Test". The control relays also are used to control bench type measuring equipment or stimuli used for special or seldom used tests.

v. Manual Section - the manual section contains stimuli as well as the manual control station for controlling tests. Manual stimuli consists of stimuli not under control of the programmer-controller. Stimuli are adjusted by the operator to provide maximum diagnostic testing capability. A manual test may be performed by an operator at this station while another operator conducts an automatic test using the other sections. During the manual mode, the test point selector may be utilized to select various test point settings. The digital multimeter and frequency counter also may be used during manual mode for measurement purposes and evaluation of results obtained.

A manual control panel contains panel meters, voltage output jacks, voltage control knobs, an ac monitor selector, a dc monitor selector, a measurement repeat switch, a variac, and a function and value in-line indicator, which may be switched in parallel with the programmer-controller in-line readout when desired. Connections to a variable ac source and a 6.3 volt ac transformer can be made at the manual control panel. Two manually controlled high voltage power supplies are provided. Each power supply is capable of delivering from 10 to 110 volts dc at 100 ma max. The power supplies may be connected in series. Power supply regulation is $\pm$ 0.1% at the manual control panel.

w. Program Board Storage is provided.

x. The adapter panel connects electronic subassemblies under test to the test set.

y. Special cables are provided for self-test and acceptance tests.

1.2 System Operation

a. During automatic testing, a punched tape program controls the SP-8A Test Set functions, automatically, as follows:

1. Appropriate interconnections are made for each test.
2. Stimuli functions are initiated.
3. The upper and lower tolerance limits of the measurement to be made are stored in the comparator.
4. Stimulation is applied to the "Unit-Under-Test".
5. Range and function selections are made on the digital multimeter or frequency counter.
6. Time delays, when required are established to allow for warmup or accomplishment of a phase of operation in the unit under test.
7. The command to measure is given to the digital multimeter or frequency counter.

Coded information from the tape reader goes to the control circuits in the programmer-timer module. The information is in binary coded form. The initial part of an information sequence is an address, and the following parts of the same sequence are commands. An address establishes the circuit paths necessary to control the functions of a selected portion of the SP-8A. With circuit paths chosen by the address, command voltages are applied by the programmer module to cause the addressed module to perform various functions. Each module, or in some cases each of several functions within a module, is assigned an address number. For example, address 13 addresses the ac signal generator, thereby closing circuit paths to the high and low limit memory circuits in that module. Spare addresses are available for selection of stimuli which may be added to the test set.

Commands to apply stimulation signals to the equipment under test are issued to modules with specific functions in the automatic stimuli section. In operation, a command signal from the programmer module is issued to actuate a relay in the control module. Contact closure of that relay applies the stimulus signal through the program board to the connector and/or adaptor panel and hence to the "Unit-Under-Test".

b. Evaluation

Signals from the Unit-Under-Test are applied through the test point selector circuits to the digital multimeter or the frequency counter. For each test measurement, high and low limits are transferred from the punched tape and stored in the comparator memory. Then the measured (digitized) value is presented by the measuring instrument to the comparator, a comparison is made between the measured value and the measurement limits. In addition, an evaluation signal (HI, LO, GO) is generated by the comparator and transmitted to the indicator and display module, the printer, and the programmer and timer unit.

To determine if the tested circuits in the equipment under test are operative, high and low limits are included on the program tape. The programmer applies data representing these directly to the comparison circuitry in the comparator. When the signal from the equipment under test is measured, it is compared with the previously established limits, and the condition of the circuitry is immediately determined. Circuit condition information is fed from the comparator through the indicator-control to the printing and visual display circuits.

c. Automatic Test Interrupt

Programmed test sequences proceed automatically and without interruption if the equipment under test contains no out-of-tolerance conditions. If an out-of-tolerance condition does occur, the test sequence stops, a visual "HI or LO" indication is displayed on the indicator-control panel, and an audible alarm is sounded. The system will not proceed to the next test sequence until the out-of-tolerance condition has been corrected by adjustment, or by manual override. Actuating the manual override switch permits the system to proceed to the next test sequence, thus permitting further isolation of latent malfunctions in the equipment under test prior to replacement or repair of a single faulty component. It also causes a test override indication to be made on the printed tape.

d. Test Results Information

Test results are printed for each test, thereby providing a permanent record. The following information is printed.

1. The test sequence number.
2. The type of measurement such as ac, dc, frequency.
3. The measured value.
4. Location of decimal point.
5. An indication of HI, LO, or GO.

The measured value is displayed on the inline readout after the digital multimeter has completed the measuring process. The readout is displayed during the manual mode of operation until initiation of the next measurement, and for an out-of-tolerance condition during the automatic operation. The test sequence indication range is from 000 to 999. The type of measurement is indicated in symbol form as follows:

1.	Alternating current	AC
2.	Direct Current	plus (+) or minus (-)
3.	Resistance	kilohms (K)
4.	Frequency/count/time/period/ratio	f/c/ t/p/fr

The digital indication of the measured value is displayed as a 4-digit number from units to thousands with proper decimal location. The comparator decision of the measurement is indicated as HI, GO or LO. WAIT appears on the readout until a programmed time delay has elapsed.

2 THE CTI MODEL 235, AUTOMATIC TESTER

The first CTI Model 235 system was put into use at North American, Space and Information Systems Division, Downey, Calif., in support of the Hound Dog missile program. The CTI 235 uses the concept of separating complex electronic test requirements into 2 separate areas of consideration, i.e., into the solution of the electronics switching requirements and then the actual measurements. Transferring this concept into actual hardware, the 235 system allows for additional inputs, expansion of the number of points the inputs are switched to, stimuli, power supplies, loads and measurement subsystems.

2.1 System Programming

The CTI 235 System is programmed with the same techniques used for programming digital computers. A series of set-up commands, general instructions such as stop, reset, make test, etc., and special test instructions are used to operate this machine. These easily understood logical instructions are represented in the machine by 2 decimal numbers, a 0 to 7 digit and a 0 to 15 suffix. System input can be accomplished manually on 2 numbered dials or automatically with a single line 8-hole paper tape reader. A Model 220 reader is normally used as the system input with one hole used for parity check; however, the system can be driven from any standard computer input.

2.2 System Switching

A Control Unit, Model 272, is used to provide the sequencing of the analyzer. It steps the reader, routes the information to the other portions of the system, carries out the general instructions, checks a code, provides a tape search function, and initiates the next step of a sequence after receipt of a signal that the previous step is completed.

A Director Unit, Model 271, is used to route program data for test set-up, including any relay sequences, stimuli, loads and measurements, and subsystem selection. The director unit also addresses the system Test Switch Units, Model 270, that provide connection to the Unit-Under-Test. A Model 271 Director Unit routes a 4 bit code to any of 240 places. This capacity is expandable by the addition of up to 10 director units for a total of 2,400 subsequence locations.

The director unit controls a Parameter Unit, Model 276, to apply the required system stimuli parameters to the Unit-Under-Test through the test switch unit. Required stimuli include any combination of power supplies, oscillators or loads that can be programmed directly by a resistance value. One parameter unit will control up to 19 system stimuli, depending on the resolution required.

The CTI Model 279, Measure Control Unit, controls the measuring instruments and integrates their operation in the system. This unit routes the proper control inputs to each unit associated with measurement, keeps track of decimal point location, and gates the measure value to the comparator and printer. This unit is normally used with a digital counter, a digital volt ohmmeter, and a digital printer for output purposes. Its design must be compatible with the digital meter and counter selected.

The measure select unit is used to select accessory conversion devices used for specific measurement requirements, such as a DC amplifier, AC-DC converter, ripple detector, etc. The basic 277 selects up to eight accessory conversion models, and up to eight additional measuring units.

2.3 System Measurement

The measurement capability of the CTI Functional Analyzer consists of a counter, to measure frequency, time intervals, period, frequency ratio, and count with a digital output, as well as a 4 digit digital volt ohmmeter. DC voltage is used as the basic measurement parameter. Accessory conversion units are provided for special measurements, including a DC amplifier with a gain of 100, a 0.25% accuracy AC-DC converter, a peak-to-peak ripple voltage converter, and a DC Hi-pot leakage converter.

The measurement section digital output is used to drive the CTI Model 278 Digital Comparator (5 digit) with the measured value signal. The CTI Model 278 Comparator stores upper and lower test limits which are obtained directly from the paper tape via the director unit. On command, the 278 comparator compares these three numbers and emits a HI-LOW-GO signal to the system indicators, the printer, and the control unit.

A digital two color printer is used as a standard system output. Standard record format provides the first three columns for test number, one column for decimal point location and five columns for the actual measured value. Rejects are printed in red.

2.4 Switching to the Unit-Under-Test

The Unit-Under-Test receives stimuli from and provides test signals to CTI Model 270 Test Switch Unit. A single switch unit module selects any group of 10 wires out of 120 from the "Unit-Under-Test" simultaneously. Any number of additional switch units or special multiple modules can be added for special purposes. With 2 switch units, either 20 lines out of 120 or 10 lines out of 240 may be selected. With 4 switch units, 40 out of 120 or 10 out of 480 lines or 20 out of 240 lines may be selected, and so on. Special switch units would be used to meet applications which might be experienced if completely random access high frequency switching were necessary, such as in logic card or module testing. Using the Standard CTI Model 235 Functional Analyzer configuration with only one test switch unit, ten lines are available for simultaneous operations. Seven of these lines are used for signal stimuli, one is a spare, and the remaining two are required for two wire signal measurement by the measurement portion of the system.

2.5 Stimuli

As described previously, expanding the number of test switch units and director units allows the use of any number and type of stimuli to the system under test. They may be added at any time. The standard 235 system and its initial configuration provides the following stimuli that can be programmed directly from the input paper tape, either directly or by the Model 276 Parameter Unit.

a. Two each 0-50 volts DC supplies, 0.5 volts steps, 500 ma, 0.5% stability.
b. One each fixed 36 volt DC supply, 500 ma, 0.05% stability.
c. One each 0-100 millivolt supply, 1 mv steps, 2% accuracy.
d. One each 0-150 volts AC rms, 1 volt steps, 700 ma., frequency 350-450 cps in 1 cps steps, voltage stability 0.25%, frequency stability 0.2 cps.
e. One each 4-8 volt AC rms, 0.04 volt steps, 150 ma., 400 cps, voltage stability 1%, frequency stability 0.2 cps.
f. One each phase shifter to provide a 4 to 8 volt AC output referenced from the high voltage AC supply that is shifted 0.2 to 180 degrees, 180.2 degrees to 360 degrees in steps of less than 1 degree.
g. 28 volts DC and 110 volts AC, 400 cps, 3 phase power plugs are provided at front panel plugs. Power can be OFF or ON by the input tape.
h. The parameter unit is a general purpose unit used to easily adapt stimuli and special circuits to the tester. It is composed of nineteen printed circuit card holders and five terminal boards. These terminal boards are used to mount programming resistors for commercial power supplies or other stimuli, or special circuits required for proper operation of any particular system. These programming resistors are selected or controlled by the printed circuit relay cards as directed from the tape. Special circuits such as the Millivolt DC Supply and Phase Shifter Amplitude Control can be contained in the parameter units. The unit can also be used to provide controllable load resistors.

2.6 Measurement Capability

The following measurement capabilities are expressed as a percentage of full scale:

a. VDC: 0.1 mv to 999 volts at 0.01%

VDC: (Low level) 1 microvolt to 9.999 mv, 0.03%, 5 microvolt stability

b. VAC: 1.0 mv to 999.9 volts at 0.1%

c. Resistance: 0.1 ohm to 999.9K ohms at 0.05%

d. Leakage: DC Hi-pot at 500 or 100 volts DC, 1 to 300 megohms, at 3% to 150 megs and 6% to 300 megs.

e. Ripple: 0 to 100 mv, peak-to-peak, at 2%

f. Frequency: 0.1 cps to 1.2 mc, 3 parts in 10^7 stability

g. Time Interval: 1 microsecond to 10^7 seconds

h. Frequency Ratio: 0 to 10^5

i. VDC Ratio: 0 to 999 at 0.01%

3. DIT-MCO MODEL 610A AND 720A

3.1 DIT-MCO Model 610A

Programming is by punched tape, punched cards, or computer buffer; the interface selected by the customer. Information readout is visual, digital printer or electrical typewriter, punched tape, punched cards, or into the input buffer of a computer. Test capacity consists of 100 to 500,000 circuit terminations, in 1000 termination increments. It has the following measurement capabilities:

a. Low Voltage Continuity Test

1. Programmable current tests of 0.1, 0.5, 1.0, 2.0, 2.5 amperes.
2. Programmable continuity resistance tests of 1 - 10 ohms, in 1 ohm steps; 10 - 100 ohms, in 10 ohm steps; 100 - 1,000 ohms, in 100 ohm steps; 1 K - 10 K ohms, in 1 K ohm steps; 10 K - 100 K ohms, in 10 K ohm steps; 100 K - 1 megohm in 100 K ohm steps.
3. Test voltage is a function of programmed test current and continuity resistance rejection limits.

b. High Voltage Leakage Tests:

1. Test current limited to 1 ma maximum.
2. Programmable Test Voltages of 100, 250, 500, 750, 1000, 1250, 1500 volts DC.
3. Programmable Leakage Resistance, with minimum acceptance values 200 K - 1 megohm, in 100 K ohm steps; 1 megohm - 10 megohms, in 1 megohm steps; 10 megohm - 100 megohms, in 10 megohm steps; 100 megohms - 1000 megohms, in 100 megohm steps.

c. Short test is simultaneous with leakage test.

d. Input power requirements are 95 to 125 volts AC, single phase, 60 cycle.

e. The following are additional options:

1. Manual override, provides manual insertion of test programming.
2. Self-Programming, generates non-redundant "as-built" program from standard unit.
3. Externalization - 100 termination module, 28 volts DC and/or 115 volts AC, 400 cycles, expandable in 100 terminations increments.
4. Four-terminal measurements, for checking extremely low values of continuity resistance.
5. Resistance value print-out, provides print-out of faulty circuit resistance.
6. Inside-out tape spooler, eliminates tape rewind on tape programmed units.
7. Non-standard program codes, for codes other than NAS.
8. Meter panel, built-in meters to read test voltages and test current.
9. Dwell time, optional dwell times of 0.1 sec. to 1 second in 0.1 second steps; 1 sec. to 10 second in 1 second steps; 10 sec. to 100 second in 10 second steps; 100 sec to 300 second in 100 second steps.

3.2 DIT-MCO Model 720A

The model 720A is an automatic Logic Circuit Tester which will rapidly and accurately test and evaluate packaged modular circuits and plug-in solid state circuit modules or cards. It operates on a HI-GO-LO basis. Fail-safe static tests are performed on either active or passive circuits. Programming flexibility allows isolation of circuits within the "Unit Under Test" to facilitate location of detected errors or component failures.

Accept or reject decisions are controlled by tolerances programmed for each measured parameter value. Connections are provided to accept external loads, signals, pulses and detectors which can automatically be switched into the test circuits by means of programming. Modular construction is used throughout. It has the following test capabilities:

a. DC voltages may be applied and/or measured:

1. 0 to 0.999 volts in 0.001 volt steps
2. 0 to 9.00 volts in 0.01 volt steps
3. 0 to 39.9 volts in 0.1 volt steps

b. Current Measurements:

1. 0 to 99.9 microamps Full Scale in 0.1 microamp steps.
2. 0 to 999 microamps Full Scale in 1 microamp steps.
3. 0 to 9.99 milliamps Full Scale in 10 microamp steps.
4. 0 to 99.9 milliamps Full Scale in 100 microamp steps.
5. 0 to 999 milliamps Full Scale in 1 milliamp steps.

c. Resistance Measurements:

1. 0.01 to 9.99 ohms in 0.01 ohm steps
2. 0.1 to 99.9 ohms in 0.10 ohm steps
3. 1 to 999 ohms in 1.0 ohm steps
4. 10 to 9,990 ohms in 10.0 ohm steps
5. 100 to 99,990 ohms in 100 ohm steps
6. 1 K to 999 K ohms in 1 K ohm steps

d. Seven DC power supplies are provided in the basic tester. All of the power supplies are selected by programming. Six of the supplies are separate, regulated sources pre-set by the operator. The seventh is a programmable supply which takes on values as programmed. Three digit voltage values from 0.001 volt to 39.9 volts are provided.

e. The following eight dwell times in steps from 0 to 1 second are programmable.

1. 200 milliseconds
2. 300 milliseconds
3. 400 milliseconds
4. 500 milliseconds
5. 600 milliseconds
6. 700 milliseconds
7. 800 milliseconds
8. 1 second

At minimum dwell time, 2 to 5 tests per second with one pin configuration per set-up is the testing speed.

f. The capacity of the standard tester is 22 pins. The model 720 can be expanded to 88 test pin terminals, in 22 pin increments.

4. HUGHES AIRCRAFT COMPANY, HCM 111A VERSITAL AUTOMATIC TESTER

The HCM111A testing system provides the flexibility of either tape-control or computer-control. This is accomplished without equipment change. For problems that are simple enough to be solved satisfactorily by tape-control, the machine may be programmed like any tape-controlled machine. For problems that are better solved by computer-control, computer control programs may be inserted by the same test tape. Both modes of control may be intermixed on the same tape. Pure interval storage of programs may also be used.

The HCM111A test system is completely modular and may be expanded in building-block fashion, permitting the user to buy only the capacity needed. The basic unit consists of a tape reader, power supplies, and a digital processor. This basic unit can be used "as is" as a fast digital computer. A wide variety of modular building-block input-output devices may be plugged into the basic unit to meet varying requirements. These input-output building blocks range from a simple one for wire checking, to high speed waveform analyzers, fast accurate analog outputs and high frequency counters. In large installations with demanding requirements, multi-station simultaneous time-sharing logic and million bit memory building blocks may be attached as desired.

The HCM111A Specifications are as follows:

a. DC voltage measurement of

1. 0-1, 2, 5, 10, 20, 50, 100, 200, 500 volts Full Scale.
2. Input impedance - up to 100 volt scale, 100,000 ohms per volt. 100, 200, and 500 volt scales, 10 megohms
3. Accuracy: ± 1% including quantization error.
4. Buffer Frequency Response: 0-500 cps.
5. A/D Conversion Time: 100 microseconds, repeatable at 6 KC rate.
6. Connections: Floating differential, up to 500 volt peak common mode permitted on any scale.

b. AC Voltage Measurement:

1. Types: Non-Phrase-Sensitive, In-Phase, and Quadrature.
2. Input Impedance: (in parallel with cable capacitance) Up to 100 volt scale; 100,000 ohms per volt. 100, 200 and 500 volts scales: 10 megohms.
3. Ranges: 0-1, 2, 5, 10, 20, 50, 100, 200, 500 rms Full Scale.
4. Accuracy: ± 0.2% including quantization error.
5. Frequency Range: 50 - 5000 cps at full accuracy; to 10,000 cps at 1% accuracy.
6. A/D Conversion Time: 100 microseconds, repeatable at 6 KC rate.

7. Connection: Floating differential: up to 500 volts peak common mode permitted on any scale.

c. Resistance Measurements:

1. Method: 2 terminal
2. Ranges: 0-100, 1 K, 10 K, 100 K, 1 megohms
3. Accuracy: ± 0.2%
4. Buffer Frequency Response To Time - Varying Resistance: 0-500 cps
5. A/D Conversion Time: 100 microseconds, repeatable at 6 KC rate

d. An ON-OFF Response Measurement indicates to the program the input voltage if from a low-impedance source, and + 50 volts if from an open source. Normally used to distinguish ground, open, and + 28 volts.

e. Frequency Measurement:

1. Range: 0 - 10,000 cps
2. Voltage: 1 - 500 volt peak
3. Waveform: Any
4. Gate Time: Any (increments of 100 microseconds)
5. Input Impedance (In parallel with cable capacitance): 10 megohms

f. Voltage Ratio Measurement: Measurement of ratio of any pair of voltages (DC, AC, AC In-phase, AC quadrature) with input properties as shown for individual voltages, above.

g. Time Measurement:

1. Range: Any
2. Granularity: 100 microseconds per step
3. Voltage: 1 - 500 volt peak
4. Waveform: Any
5. Input Impedance (In parallel with cable capacitance): 10 megohms

h. Parallel Digital Measurement:

1. Levels: Zero and positive, or ground and open
2. Parallelism: 12 bits per sample

i. Serial Digital Measurement:

1. Levels: Zero and positive, or ground and open
2. Clock Rate: 200 KC
3. Clock and envelope waveform: supplied by tester.

j. Waveform Analysis:

Basic

1. Bandpass: 0-500 cps
2. Sampling Rate: 0-6 KC
3. Accuracy: 0.1% voltage, 0.005% time
4. Connection: Floating differential, up to 500 volt peak common mode permitted.
5. Type of Waveform: Single transient or repetitive

Option #1

1. Bandpass
2. Sampling Rate: 6 KC
3. Accuracy: 0.1% voltage, 0.005% time
4. Type of Waveform: Single transient or repetitive

Option #2

1. Bandpass: 0 - 20 mc
2. Type of Waveform: Repetitive
3. Sample width: 10 nsec
4. Sample spacing: Any
5. Accuracy: 2% voltage, 0.5% time

k. ON-OFF or Parallel Digital Stimulus

1. Parallelism: 10 bits per word
2. Basic type: SPDT relay contact, floating

3. Basic capacity: 500 volt maximum; 2 amp resistive at 115 volts AC or 28 volts DC

Optional

1. Type: Semiconductor switch to ground
2. Capacity: + 100 ma, + 40 volts

l. Fast DC voltage Stimulus

1. Use: Waveform generation, stimulus control, entry of tester into servo loops, direct DC stimulus
2. Range: 8 volts DC
3. Accuracy: $\pm$ 0.1%
4. Slewing speed: 2000 volt/sec.
5. Updating interval: 100 usec

m. Digital Processing Capabilities

1. Tape speed: 300 characters per second, reversible
2. Tape code: Any
3. Tape style: 8 level paper or mylar

n. Computer Control Mode:

1. Speed: Basic 33,000 operations per second with split memory or separate program memory: 69,000 operations per second.
2. Word Size: 24 bits including sign
3. Orders: 12 bits

5 <u>THE AN/GJQ-9</u>

The AN/GJQ-O is an automatic programmer for checkout sequencing of subsystems and systems for test. It is designed to provide by use of a perforated tape a flexible program for automatic controlling any subsystem test program or checkout sequence that may be required by a weapon system as applied to aircraft and guided missiles. The automatic programming control is provided by a network of logic and memory circuits that are joined together through a switching complex. The various operational elements to automatically accomplish the required test sequence are programmed by a binary coded tape reader and decoding system.

The automatic programming control contains the following basis functions:

a. Selection of proper stimuli control channels to be applied to the system under test.
b. Selection of measurement channels for connection to the proper test points in the system under evaluation.
c. Direction of appropriate measurement and evaluation devices as to the type and range of measurements to be made on the selected test points.
d. Introduction of time delays as required for proper functioning of the system under test.
e. Selection and insertion of proper measurement tolerances into limit storage devices.
f. Regulation of program continuation, as required, based upon results of evaluation and measurement functions or temporary hold program conditions as directed by the tape.
g. Actuation of visual and printed readout devices to reflect test and test status data as required.

5.1 Measurement and Evaluation Capability

The measurement and evaluation capability shall be provided basically by a binary coded network wherein a parallel comparison is made of each test point measurement value by a digital computation process, with both high and low tolerance limits simultaneously. The resultant decision is provided as a GO or NO-GO output signal. The measurement and evaluation system shall include the necessary range selection, voltage rectification, and signal conversion facilities, as well as limit storage devices to accomplish the following functions related to the measurement and evaluation capabilities:

a. Selection of type and range of measurement to be made on any test point signal as directed by the tape program.

b. Normalization of test point signals to signals compatible for use by the measurement and evaluation system.

c. Conversion of analog - measured values into digital numbers for comparison with stored, digital upper and lower test value limits.

d. Storage of upper and lower digital test limits as directed by automatic programming.

e. Digital comparison of measured value with stored test limits.

f. Provision of evaluation results as visual or printed readouts as required.

5.2 Measurement Capability

Manual programming capability is provided as well as auto checking of tape information by odd parity and complete logic self test provisions. The time, frequency, voltage and resistance measurement capabilities are as follows:

a. DC voltage Measurement

1. Ranges: .999, 9.99, 99.9, and 999 volts DC.
2. Input Impedance: 100,000 ohms/volt, 10 meg. maximum
3. Accuracy: ± 0.1% of range, 1 digit maximum
4. Resolution: 1 part in 1,000
5. Analog to digital conversion time: Less than 100 microseconds
6. Capacitance between differential input leads: Less than 3000 picofarads.
7. Capacitance between input leads and ground: balanced to within ± 10%.

b. AC voltage measurement

1. Ranges: .999, 9.99, 99.9, 999 volts AC
2. Indication rms value of sinusoidal voltage: 1.11 times average value of nonsinusoidal voltages.
3. Input Impedance: 100,000 ohms/volt, 10 megohms maximum

4. Frequency Range: 600 to 10,000 cps.
5. Accuracy: $\pm$ 1% of range, 1 digit maximum, from 60 cps to 5 KC.
6. Resolution: 1 part in 1000
7. Analog to digital conversion time: Less than 90 milliseconds
8. Capacitance between differential input leads: Less than 500 picofarads.
9. Capacitance between input leads and ground: Balanced to within + 10%.

c. Voltage Ratio Measurements:

1. External reference signal ranges
   0.1 to 1.0 volts
   1.0 to 10 volts
   10 to 100 volts
   100 to 500 volts
2. Reference signal: AC or DC
3. Input Impedance: 100,000 ohms/volt, 10 meg. maximum
4. Frequency range: 60 cps to 10 KC
5. Response Time: 90 milliseconds
6. Accuracy: AC $\pm$ 1% of range, 1 digit maximum 60 cps to 5 KC
   DC 0.1% of range, 1 digit

d. Resistance Measurements:

Range	Voltage Open Circuit	Current Short Circuit	Accuracy
0-100 ohms	1.0 volt	10 ma	1%
0-1,000 ohms	1.1 volt	1.1 ma	1%
0-10,000 ohms	10.0 volt	1.0 ma	1%
0-100,000 ohms	100.0 volt	1.0 ma	1%
0-1 megohm	300.0 volt	0.3 ma	3%

e. Frequency Measurements

1. Range: 0.1 cps to 1.0 mc

2. Auxiliary Timer:

   Ranges: 1, 10, and 100 sec.

   Gating Times: 0.01, 0.1, 1.0, 10, and 100 sec.

   Gate Accuracy: 0.001%

3. Input voltage: 1.0 volt minimum, 500 volt maximum (DC or peak AC)

4. Input impedance: 100,000 ohms/volt

5. Input Waveform: Pulse (1.0 volt/second minimum rise time).

f. Counter-Timer:

1. Maximum count: 6 decimal digits
2. Maximum counting rates: 1 megacycle/second
3. Input Waveform: Pulse (1.0 volt/sec. minimum rise time)
4. Input impedance: 100,000 ohms/volt
5. Timer interval oscillator:

   Frequency: 100 or 1,000 cps

   Accuracy: 1.0 pulse per minute

6. Ranges: 999, 9990, 99900, and 999000.
7. Output Readable: Four ranges, three digits at a time.

5.3 Program Control Capacity

The programming set is capable of selecting up to 200 test points for measurement which includes 100 channels for system stimuli control. The control and selection logic capacity is capable of selecting a maximum of 2,000 test points for measurement and 300 stimuli control channels. All switching required to accomplish the automatic programming is accomplished by a network of logic and memory circuits. These circuits are designed to operate on a synchronous basis using flip-flop controlled gating elements. The triggering source for driving the flip-flops to accomplish the simultaneous switching is provided by the system clock at a rate of 4,000 cps.

6. GENERAL ELECTRIC AND MARTIN MARIETTA MODULE TESTERS

The General Electric and Martin Marietta Module Testers were designed to perform automatic test of analog and digital logic modules. This includes the complete range of digital and analog module cards.

7. THE DYMEC DIVISION OF HEWLETT-PACKARD AUTOMATIC SYSTEMS

The Model 5844C Automatic Waveform Measuring System is a system for measuring dynamic parameters of transistors, diodes, magnetic cores, high-speed components and circuits. The main features are as follows:

a. Simultaneous digital display of rise, fall, delay, and storage times, diode reverse recovery times, pulse widths of any pulse waveform either repetitive or transient.
b. Makes pulse amplitude and pulse area measurements and provides automatic nominalization of all pulse amplitude and displays digitally in any 4 parameters.
c. Binary outputs from the decades for easy recording and "GO-NO-GO" comparison.
d. Resolution up to 1 part in 10,000 or 50 picoseconds.
e. Provide real time testing at clock rates to 100 mc.

The DY-6100 is a voltage scanning system that is used for automatic measurement of multiple DC or AC voltages. The main features of the DY-6100 are as follows:

a. Provides digital measurements of DC voltages from .001 volts to 750 volts.
b. Scanning rate at 50 single wire or 25 two wire inputs, with scan limit control.
c. All measurements are printed on paper tape with channel identification number.
d. The noise rejection is 44 db at 60 cps.
e. Accuracy is ± 0.2% of reading ± 1 digit from 50 cps to 50 KC.
f. Input impedance is 11 megohms.
g. Response is 50 cps to 100KC, AC voltage measurement with optional AC converter.

The DY-2010A is a data acquisition system used for digital measurements of analog inputs, even under noisy signal conditions. The main features of the system are:

a. Accurate digital measurements of DC inputs down to 0.1 volt
b. Frequency measurements from 10 to 100,000 cps.
c. AC voltage measurements from 50 cps to 100,000 cps
d. Resistance measurements from 100 ohms to 10 megohms full scale.
e. Provides a 105 db effective common mode rejection of all noise frequencies for DC voltage measurements.
f. Automatic scanning of 25 three wire inputs; expandable up to 100 channels.
g. Completely self programming capability for selection of type of measurement, range, etc.

The model DY-2010D is another data acquisition system with the following main features:

a. Measures directly up to 200, three wire thermocouple and strain gage signals in the presence of high common mode noise.
b. Records the measurements on perforated tape in computer-compatible format.
c. Provides continuous recording at 110 characters/second and provides 600 channels/minute measuring rate.
d. Better than 130 db effective common mode rejection at all frequencies, including DC.
e. Provides a choice of 600 one-wire, 300 two-wire, 200 three-wire or 100 six-wire inputs.
f. Input impedance 1 megohm on 1 volt and higher ranges. 100 K on 0.1 volt range.

In addition to the above package systems, there are available the following digital instruments for packaging:

a. Model DY-2911 Guarded Crossbar Scanner is a multi-channel input scanner where high noise rejection is required.
b. Model DY-2901 Input Scanner/Programmer provides automatic multi-channel, low-level input scanning.
c. Model DY-2742 Digital Data Translator permits graphical plotting of digital information from punched cards or perforated tape.

d. Model DY-2545 High Speed Tape Punch Set permits recording digital information on perforated paper tape.

e. Model 2540 Coupler scans input data, translates it into code and format required by various data recorders.

f. Model 2533/6 One Line Digital Displays are available for visual display of digital information in electronic instrumentation systems.

g. Models 2532A and 2538 Digital Comparators compare measurements made with electronic counters and digital voltmeters with preselected or determined limits.

h. Model DY-2500 Computing Counter is available for measurements of frequency, period and frequency ratio.

i. Model DY-2530 Binary/Decimal Register stores and translates parallel data for entry into card punches, comparators, and displays.

j. Model DY-2460A Amplifier is a widband high-gain amplifier with plug-in versatility.

k. Model DY-2401A Integrating Digital Voltmeter is a 5 digit visual readout voltmeter of high accuracy to 300 KC.

l. Model DY-2410A AC/Ohms Converter is a programmable AC volts and ohms to DC converter.

From any of the above instruments, a system could be assembled which would be digital in operation for memory storage, and tape programmed or computer controlled with scratch pad memory similar to the Hughes Model HCM111A. It would be capable of doing the testing required for the stage components.

8. AIRCRAFT ARMAMENTS, INC.

This automatic test set was designed for use with the AN/MPQ-36 Nike Simulator System. This test set has the ability to test individual modules, such as, IF amplifiers, video amplifiers, servo amplifiers, digital logic circuits, and electromechanical servo assemblies. The test set is intended primarily as an automatic device. It is also possible to control the test set equipment by manual controls. The controls were designed for convenient manual operations by the operator in order to allow concentration on test analysis rather than on the control aspects:

The test set stimuli are listed as follows

a. DC POWER SUPPLIES

Voltage	Accuracy	Current	Range
± 150 volts	.1%	200 ma	130 to 165 volts in 5 volt steps
± 150 volts	.1%	200 ma	130 to 165 volts in 5 volt steps
± 300 volts	.1%	200 ma	125 to 300 volts in 25 volt steps
± 300 volts	.1%	200 ma	260 to 330 volts in 10 volt steps
± 6 volts	.1%	1 amp	4.0 to 8.0 volts in 1 volt step
± 12 volts	.1%	1 amp	9.0 to 16.0 volts in 1 volt step
± 16 volts	.1%	1 amp	15.0 to 22.0 volts in 1 volt step
± 24 volts	.1%	1 amp	18 to 32 volts in 2 volt steps
- 28 volts	10%	5 amp	fixed
± 50 volts	.1%	100 ma	programmable in .5 volts steps from 0 to 50 volts
± 500 volts	.1%	100 ma	programmable in 5 from 0 to 500 volts

b. AC POWER

Voltage	Frequency	Current
120 VAC ± 10%	400 cps ± 5%	3 A, 1 phase
120 VAC ± 10%	60 cps ± 5%	5 A, 1 phase
120 VAC ± 10%	60/400 cps ± 5%	5 A, 3 phase (4 wire wye connected)
6.3 VAC ± 10%	60/400 cps ± 5%	2 amp supplies
11.8 VAC ± 10%	400 cps ± 5%	20 W, 3 phase
26 VAC ± 10%	400 cps ± 5%	20 W, 3 phase
69.3 VAC ± 10%	400 cps ± 5%	20 W, 3 phase
120 VAC ± 10%	400 cps ± 5%	20 W, 3 phase
6.82 VAC ± 10%	400 cps ± 5%	20 W, phase B and C
30 VAC ± 10%	400 cps ± 5%	20 W, phase B and C
20 VAC ± 10%	400 cps ± 5%	20 W, phase A = 180°
90 VAC ± 10%	400 cps ± 5%	20 W, phase A + 180°
120 VAC ± 10%	400 cps ± 5%	20 W, phase A + 180°

c. SIGNAL SOURCES

1. Pulses	2 pulses .1 usec to 900 usec wide	± 5%
	PRF: 10 cps to 90 KC	±
	Delay: 1 usec to 9,000 usec between pulses	
	Amplitude: 50 volts into 90 ohms attenuated from 0 to 59 db in 1 db steps	± 5%
2. Audio (Sine or squarewave)	.01 cps to 100 KC	± 3%
	Amplitude: sine wave, 3.16 V rms squarewave, 1 volt into 600 ohms attenuated from 0 to 59 db in 1 db steps	± 3%

3.	RF Generator	50 KC to 96 mc in 7 bands Amplitude: sine wave, 1 V rms into 50 ohms attenuated from 0 to 99 db in 1 db steps	± 25%

NOTE: RF output pulse may be modulated by .25 to 5 usec wide external input pulse.

4.	Ramp	10^2, 10^3, 10^4, 10^5, volts/second Voltage ramp of 0 to plus or minus 10 volts and 0 to plus or minus 100 volts. Ramp starts at sync input.

The measurement system consists of many instruments and devices. Various combinations of these are used in order to perform each type of measurement which can be made by the test set. For each measurement the proper devices are interconnected by relays controlled by the logic system. The following represents the test sets' measurement capability:

a. MEASUREMENT CAPABILITY

Measurement	Range	Accuracy	Input Impedance
DC volts	.1 V	± .1% FS	100 K floating
	1 V	± .1% FS	1 meg
	10 V	± .1% FS	1 meg
	100 V	± .1% FS	1 meg
	1000 V	± .1% FS	1 meg
AC volts	.1 V	± 1% FS	1 meg floating
	1 V	± 1% FS	1 meg
Max. of 750	10 V	± 1% FS	1 meg
volts rms	100 V	± 1% FS	1 meg
	1000 V	± 1% FS	1 meg

Measurement	Range	Accuracy	Input Impedance
Ohms	.1 K	± .15% FS	Floating, input negative with respect to return, max. of -20V across input terminals
	1 K	± .15% FS	
	10 K	± .15% FS	
	100 K	± .15% FS	
	1 meg	± .15% FS	
	10 meg	± .5% FS	
RF volts	1 - 3 mv	± 10% FS	Greater than 10K and less than 3 PF
	3 - 10 mv	± 10% FS	
80 KC to	10 - 30 mv	± 10% FS	
100 mc	30 - 100 mv	± 10% FS	
	100 - 300 mv	± 10% FS	
	300 - 1000 mv	± 10% FS	
	1 - 3 V	± 10% FS	
Frequency	10 cps to 100 KC (.1 to 750 volts)	± .02% of reading ± 1 count	100 K ohm shunted by 300 PF
	10 KC to 25 mc (.1 to 4 volts)		50 ohms
extender	25 mc to 80 mc (.1 to 4 volts) mixer frequencies 30, 40, 50, 60, 70 mc	± .02% of reading ± 1 count	50 ohms
Period	1 usec to 100 sec. (.1 to 750 volts)	± .3% of reading (with a 60 db signal to noise ratio)	100 K ohms shunted by 300 PF
Time Interval	1 usec to 100 sec.	± .02% of reading ± 1 count	50 ohms

Measurement	Range	Accuracy	Input Impedance
Phase measurement time difference between 0 volt crossing of 2 sine wave forms	20 cps to	$\pm$ .5° $\pm$ .1 usec.	greater than 100 K ohms
Pulse Amplitude Measurement	.1 to .3 volts .3 to 1 volt 1 to 3 volts 3 to 10 volts 10 to 30 volts	$\pm$ 10% FS $\pm$ 10% FS $\pm$ 10% FS $\pm$ 10% FS $\pm$ 10% FS	50 ohms
Pulse Width	.1 usec to 1 usec. 1 usec to 10 usec	$\pm$ 10% FS $\pm$ 10% FS	50 ohms
Pulse Train	1 usec to 100 second	$\pm$ .02% of reading $\pm$ 1 count	50 ohms
Voltage Pick Off (time from t_o until voltage reaches a predetermined level)	0 to 300 volts	$\pm$ 20 millivolts $\pm$ 2 usec	200 K
Average voltage measurements (average absolute value of voltage over 10 sec or 100 sec period)	.1 V to 1,000 volts in steps of X10 frequency .01 to 100 cps	$\pm$ 5% FS	100 K ohms

Measurement	Range	Input Impedance
Measurement	a) 60 db RF amplifier (10 to 100 mc) b) RF pulse detector c) Probe and amplifier (pulse signals) (3 meg input)	These items may be used to increase the sensitivity or for higher input impedances to the measurement circuits.

The test set logic controls the operation of the test set in the automatic mode of operation from information obtained from the program tape. This information is in the form of characters and numbers all of which are found on the typewriter keyboard. These test operations are made up of a series of these operations. These subroutines are as follows:

a. Module Test Search
b. Instruction Subroutine
c. Stimuli Control Subroutine
d. Measurement Control Subroutine
e. Switching Control Subroutine
f. Test Subroutine
g. Test Adjust Subroutine
h. Evaluation Subroutine
i. Standby Subroutine
j. Delay Subroutine
k. Print Subroutine
l. Fault Isolation Subroutine
m. Step Number Subroutine
n. Paragraph Number Subroutine

The programming of the tests is an important part of the overall test equipment design and requires a significant effort. Operators with very little training will be quite capable of preparing programming tapes if provided with the necessary information, but the test set design of comprehensive tests requires capable programming personnel with circuit design experience.

LISTING AND DESCRIPTION OF STAGE MECHANICAL AND PNEUMATIC COMPONENTS

1. Mechanical and pneumatic components are listed as follows:

Qty/Stage	Part No.	Title
1	1A48240-1	Valve, Fill and Drain
1	1A48257-1	Valve, Vent and Relief, Fuel Tank
1	1A48312-1	Valve, Vent and Relief, Oxidizer
1	1A49591-1	Valve, Relief, Fuel Tank
1	1A49590-1	Valve, Relief, Oxidizer Tank
1	1A49983-1	Separator, Vent, Zero Gravity
1	1A49988-1	Valve, Directional Control, Fuel Vent
1	1A49993-1	Module, Fuel Tank Pressurization
1	1A49989-501	Module, Repressurization, Propellant Tank
1	1A49398-1	Module, Cold He Fill
1	1A49992-1	Module, LO_2 Tank Pressurization
1	1A49989-1	Module, Repressurization, Propellant Tank
1	1A58345-1	Module, Pneumatic Power Control
6	1A49982-501-1	Module, Actuation Control
2	1A58347-1	Module, Control, Engine Pump Purge
1	1A49421-1	Pump, LH_2 Aux. Mtr. Driven, Chilldown
1	1A49423-1	Pump, LO_2 Aux. Mtr. Driven, Chilldown
2	1A49968-1, -501	Valve, Propellant Tank Shut-off
2	1A49964-1	Valve, Swing Check Chill System
2	1A49965-1, -501	Valve, Solenoid, Shut-off, Chill System
1	1A67913-1	Valve, LO_2 Chilldown, Mtr. Container
1	1A57350	Module, He Fill
1	7851861-1, -501	Disconnect Assy., Fuel (SIB) Pre-Press.
1	7851844-1, -501	Disconnect Assy., Cold He Fill

Qty/Stage	Part No.	Title (contd.)
2	7851823-503, -505	Disconnect Assy., He Fill
1	1A49958-1, -509	Disconnect Assy.
1	1A49958-507, -513	Disconnect Assy.
6	1A49958-501, -509	Disconnect Assy.
1	1A49958-503, -511	Disconnect Assy.

2. A description of six representative components with their respective test requirements are as follows:

a. Oxidizer Tank Vent and Relief Valve

The Oxidizer Tank Vent and Relief Valve, DAC P/N 1A48312, provides for both venting and pressure relief in the oxidizer tank. The assembly includes two position indicators and a helium pressure actuator. The actuator is used to pneumatically open the valve and assist its return to the closed position. Control of the helium actuation pressure is not an integral part of the valve. One position indicator indicates the open position of the valve, the other the closed position.

The valve shall open in a maximum of 0.1 second after solenoid actuation and shall close in a maximum of 1.0 second upon release of actuation pressure. Flow rate of 20 #/second at 44 psia with oxygen at -297°F and outlet pressure at sea level ambient. The relief function of the valve has a maximum cracking pressure of 41 psia and a minimum reseat pressure of 37 psia. At 31 psia the minimum flow rate is 3.8 lb/sec at sea level ambient outlet pressure.

This valve is tested as item I-7 on the Saturn IB/V S-IVB Test Plan, SM 41412 and JWO 0039 of EWO 26131. In addition to the operational test described below, this valve receives a Proof, Burst, Axial Load, Shear, Bending Moment, Vibration, Acceleration, Thermal/Vacuum, Leakage, Flow, Shock, Crack and Reseat, High Temperature, Humidity, and Repeated Cycle Test.

(1) Operational Test:

The valve is stabilized at -300°F for this test. Test the opening and closing times and position indicator switches by applying and removing a 475 psig helium gas pressure to the "open" port. Test the cracking and reseating pressures by gradually applying -300°F nitrogen gas to the inlet port until the valve cracks open. Then permit the pressure to decay until the valve reseats. The relief valve flow rate is tested by applying and maintaining -300°F nitrogen gas to the inlet port at 29.3 psig while checking flow rate at the outlet port. Flow rate of the venting function of the valve requires applying and maintaining -300°F nitrogen gas to the inlet port at 21.3 psig while applying 475 psig helium to the actuator "open" port. The flow rate is checked at the outlet port.

b. LO_2 Tank Pressurization Control Module

The LO_2 Tank Pressurization Control Module, DAC P/N 1A49992 controls the pressurization of the LO_2 tank. As the tank pressure builds up or decays, the tank pressure control switch closes and opens the normally open by-pass valve in the module. Normally a percentage of cold helium shall be heated in the heat exchanger and then be mixed with the cold helium before entrance into the tank. If the tank pressure builds up, the pressure control switch shall close the by-pass valve, thus reducing the amount of cold helium passing through the heat exchanger.

The module contains a filter, a pressure regulator, a pressure switch, two solenoid valves, three removable restrictors, a check valve and AND10050 bosses for component and flange leak check. The module shall be used for high pressure, cold helium, pressurization control in the oxidizer tank pressurization system. A plenum chamber shall be provided. It shall be welded titanium alloy or stainless steel sphere with two flanged openings having a minimum volume of 250 in^3 with working temperature range of -423 to +160°F and system pressure of 1600 psig.

This module is tested as item I-3 on the Saturn IB/V S-IVB Test Plan SM 41412 and JWO 0020 of EWO 26131. In addition to the operational test described below the module receives a Proof, Burst, Vibration, Acceleration, Thermal Shock, Electromagnetic Interference, Thermal/Vacuum, Leakage, Flow, Shock, High Temperature and Repeated Cycle Test.

(1) Operational Test:

The module is stabilized at -423°F and the back-up pressure switch electrically disconnected except as noted. The testing media is -423°F helium gas.

The check valve is tested by gradually applying pressure to the inlet by-pass port until the check valve cracks open. By applying 3100 psig to both inlet ports and energizing the solenoid valve with the proper vdc the valve may be tested for current draw and operation. Connect electrically the solenoid valve and back-up pressure switch. By capping all ports and applying pressure at the by-pass inlet the operation of the solenoid valve and back-up pressure switch can be tested. The gas flow through the module, regulated by the orifices, is tested by supplying the module with -400°F high pressure helium and checking the flow rate at each of the two outlet ports. The by-pass valve is energized and the adjusted flow rates tested.

c. Pneumatic Power Control Module

The pneumatic power control module, DAC P/N 1A58345, regulates the ambient helium from the LH_2 tank re-pressurization storage supply that is used to provide power for the various stage valves and purge modules. Helium is stored at 3100 psig and is regulated to 490 psia.

The module contains a filter, a pressure regulator, a normally open shut-off solenoid valve, a 100 cubic inch plenum chamber, a pressure switch and normally closed 3-way solenoid vent valve. The shut-off valve and pressure switch are downstream of the regulator and act as a back-up in case of a regulator failure.

The module shall withstand a proof pressure of 4800 psig and shall have a minimum service life of 1000 cycles. At 3100 psig, the external leakage shall be less than 1 scch and the internal leakage less than 10 scim. The pressure switch actuates at 535 psia and de-actuates at 450 psia.

This module is tested as item J-3 on the Saturn IB/V SIVB Test Plan, SM-41412, and JWO 0017 of EWO 26131. In addition to the operational test, described below, it receives a Proof, Burst, Vibration, Acceleration, Electro magnetic Interference, Thermal/Vacuum, Leakage, Flow, Shock, Crack and Reseat, High Temperature and Repeated Cycle Test.

(1) Operational Test:

The solenoid valves are tested by removing the plenum and regulator and applying pressure directly to the valves. Each valve is tested for operation at the proper vdc and current draw.

The pressure switch and shut-off valve are tested by connecting the plenum and capping the module outlet. After connecting the switch and valve electrically pressure is gradually applied to the shut-off valve (normally open) until the pressure switch actuates and closes the valve. Pressure downstream is then allowed to decay until the pressure switch de-actuates and the valve opens.

The regulator is then re-installed and operating pressure applied to the module inlet port. The regulator is tested for lock-up pressure, leakage and flow rate.

d. Propellant Tank Repressurization Control Module

The Fuel Tank Repressurization Control Module, DAC P/N 1A49989-501, controls the repressurization of the fuel tank following venting and just prior to re-start. The re-pressure control switch shall open the shut-off valve in the module and allow helium from the storage supply to re-pressurize the tank.

The module contains two filters, two check valves, a solenoid shut-off valve, a solenoid dump valve, a pressure relief valve, a removable restrictor, and AND 10050 bosses for component and flange leak check.

The module shall withstand a proof pressure of 4800 psia and shall have a minimum service life of 1000 cycles. At 3100 psia the external leakage shall be less than 1 scch and internal leakage less than 10 scim.

This module is tested as item J-2 on the Saturn IB/V S-IVB Test Plan, SM-41412, and JWO 0058 of EWO 26131. In addition to the operational test described below, it receives a Proof, Burst, Vibration, Acceleration, Electromatic Interference, Thermal/ Vacuum, Leakage, Flow Shock, Crack and Reseat, High Temperature and Repeated Cycle Test.

(1) Operational Test:

Stabilize the module at ambient temperature and cap the ports to the supply bottles. Gradually apply helium gas pressure to the inlet port and test the cracking pressure of the check valves. Increase the pressure to 3100 psig and test the operation and current draw of the dump valve by applying the proper vdc to the valve solenoid. De-energize the dump valve and increase pressure to test the cracking pressure, flow rate and reseat pressure of the relief valve. Reduce pressure to 1485 psig, energize the normally closed shut-off valve, and test for proper vdc, current draw of the valve and gas flow through the restrictor at the outlet port.

e. Fuel Tank Pressurization Control Module

The Fuel Tank Pressurization Control Module, DAC P/N 1A49993-1, controls pressurization of the fuel tank during mainstage operation. Hydrogen gas bled from the engine passes through a control orifice in this module. There are two additional orifices in parallel to the main control orifice. These orifices are controlled by a control valve and step-pressure valve.

The module also contains a by-pass valve to permit pre-pressurization of the tank direct from a ground source through the umbilical disconnect, by-passing the control orifices. Two check valves prevent any back flow to the engine or umbilical disconnect.

The module shall withstand a proof pressure of 938 psig and have a service life of 1000 cycles.

This module is tested as item H-2 on the Saturn IB/V S-IVB Test Plan SM-41412, and JWO 0019 of EWO 26131. In addition to the Operation Test described below, it receives a Proof, Burst, Virbration, Acceleration, Thermal Shock, Electromatic Interference, Thermal/Vacuum, Leakage, Flow, Shock, Crack and Reseat, High Temperature and Repeated Cycle Test.

(1) Operational Test:

The module is stabilized at $70^{\circ}F$ for these tests and $-300^{\circ}F$ helium gas used as test media. By gradually applying pressure to the umbilical inlet port the cracking pressure of the check valve is tested. Pressure is increased to 600 psig and the by-pass valve tested for operation with proper vdc and current draw. Test for valve response time and flow through outlet port.

Pressure is then gradually applied to engine port and the check valve cracking pressure tested. Flow through the control orifice is tested by increasing pressure to operating pressure. Operation of the control valve and step pressure valve permit flow testing of the other two orifices.

f. Cold Helium Fill Module

The Cold Helium Fill Module, DAC P/N 1A49398, acts as a check valve for the ground filling operation of the eight cold helium storage spheres located in the LH_2 tank. It also contains a relief valve and dump valve which protects the oxidizer pressurization system between the storage bottles and the LOX Pressurization Module.

The module must operate in a temperature range of -420 to $165^{\circ}F$ and at a pressure of 3100 psig. It has a minimum helium gas flow rate of .250 lb/sec. at 600 psia at a temperature of $-285^{\circ}F$. It must withstand a proof pressure of 4800 psia and a minimum burst pressure of 8000.psia.

This module is tested as item I-2 on the Saturn IB/V S-IVB Test Plan, SM 41412, and JWO 0018 of EWO 26131. In addition to the Operation Test described below, it receives a Proof, Burst, Vibration, Acceleration, Thermal Shock, Electromatic Interference, Thermal/Vacuum, Leakage, Flow, Shock, High Temperature and Repeated Cycle Test.

(1) Operational Test:

Stabilize the module at ambient temperature and cap the outlet ports. Gradually apply -400°F helium gas pressure at the inlet port and test the cracking pressure of check valve. Increase pressure to 3100 psig. Check the dump valve for required energizing voltage and current draw. When de-energized the valve should return to its normal position. Increase the pressure further until the relief valve cracks open and test the flow rate through the valve. At 3600 psig and a temperature of -400°F it should flow 40 lb/min of helium gas.

LISTING AND DESCRIPTION OF THE STAGE HYDRAULIC SYSTEMS COMPONENTS

1. The following list contains the subassemblies of the S-IVB hydraulic system which are on the lowest replaceable level for the system after installation.

Qty/Stage	Part No.	Title
2	1A66248	Actuator Module
1	1A78155	Accumulator Reservoir Module
1	1A66241	Auxiliary Pump Module
1	1A66240	Engine Driven Hydraulic Pump

2. DESCRIPTION AND TEST REQUIREMENTS

a. Actuator Module

The actuator assembly is a manifold unit utilizing cartridge type valves. It uses mechanical feedback of the actuator position through linkage to a torque summing point in the servo valve.

Test Requirements

The actuators will undergo the following outlined tests:

1. Proof pressure testing of hydraulic ports.
2. Electro-mechanical position and response tests of the actuator assembly.
3. Determination of servo network characteristics.
4. Functional test of the actuator piston position potentiometer.
5. Functional tests of:
   a. Prefiltration Valve
   b. Piston By-Pass Valve
   c. Piston Position Indicator
   d. Bleed Sampling Valve

b. Accumulator

Contains reservoir assemblies which will undergo the following tests:

1. Proof pressure testing
2. Freedom of motion of accumulator piston and leakage checks
3. Leakage test of relief valves and quick disconnect
4. Functional test of reservoir piston position potentiometer

c. Auxiliary Pump Module

The auxiliary motor driven hydraulic pump is powered by a 56 volt DC source and has a rated output of 1.5 gpm and 3150 psi maximum. The integrated motorpump assembly combines the following principle components:

1. Electric motor
2. Variable delivery pump
3. Valve manifold
4. Motor canister
5. Mounting

Test Requirements

The auxiliary pump modules will undergo the following tests:

1. Steady-state rated delivery test at maximum full-flow pressure
2. Pressure cycling test per MIL-P-19692
3. Rated discharge pressure test per MIL-P-19692
4. Transient response test at extremes of bus voltage
5. Check motor-pump after functional tests for contamination in bowl and filter.

d. Engine Driven Hydraulic Pump

The pump is a high pressure, piston type, variable displacement pump. The pump is the main source of hydraulic flow and pressure for a hydraulic gimbal system for a liquid hydrogen and oxygen engine. The pump is directly connected to rotating engine components and functions only during rocket engine firing.

The pump will be capable of delivering a minimum of 7 gpm while operating at the following conditions:

Speed, maximum - 7,000 rpm
Outlet pressure, minimum - 3,550 psig
Inlet pressure, maximum - 150 psig

The engine driven hydraulic pump will be proof pressure tested and subjected to a two hour functional test to determine speed-flow characteristics and also note shaft internal case leakage.

3. AUTOMATIC BENCH TESTING OF MECHANICAL, PNEUMATIC AND HYDRAULIC COMPONENTS

This equipment, in Appendix D and E, does not readily lend itself to testing with automatic methods. In fact, attempting to test these components with an automatic electrically controlled test set is indeed, impractical for the following reasons:

1. Testing consists primarily of pressures, temperatures, flow rates, leakage and mechanical motion or positioning. Because of this requirement measurements and stimuli are better controlled by other than an automatic electronic test set, i.e., fixtures with pressure and thermal capabilities.
2. The majority of the test time is in set-up and not in performance.
3. Automatic Test Equipment for mechanical, pneumatic and hydraulic components is not readily available.
4. Progressive inspection is performed on all mechanical, pneumatic and hydraulic components throughout manufacture and operational testing, before and after installation on the stage. Bench functional testing with automatic equipment, therefore, is not recommended for mechanical, pneumatic and hydraulic components.

LISTING OF ALL MODELS OF STAGE ASSEMBLIES FOR SATURN IVB AND V

1. List of Stage Assemblies:

SATURN IB

Model Number	Sect. No.	Title
DSV-4B-2-1	1000	SPACE VEHICLE, S-IVB STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1010	VEH STRUCTURES ASSY, S-IVB
	1020	SKIRT ASSY, FWD
	1023	INSTL, T/M ANTENNA CABLE SYS
	1026	INSTL, R/S ANTENNA CABLE SYS
	1027	INSTL, T/M & R/S ANTENNAS
	1030	TANK ASSY, LO2 & LH2
	1075	THRUST STRUCTURE INSTL
	1060	SKIRT INSTL, AFT
	1080	TUNNEL INSTL, EXTERIOR
	1090	INSULATION INSTL, LH2 TANK
	1100	MARKINGS INSTL
	1110	PROPULSION SYS INSTL, COMPLETE
	1120	ENGINE INSTL
	1130	ENGINE CHILLDOWN INSTL
	1135	ENGINE CHILLDOWN MOTORS
	1140	PNEU SYS INSTL, AUTO LEAK CHECK
	1150	MAIN OXIDIZER TANK COMPONENTS INSTL
	1160	MAIN FUEL TANK COMPONENTS INSTL
	1170	PNEU INSTL, MAIN FUEL TANK REPRESSURE
	1190	PNEU INSTL, MAIN OXIDIZER TANK PRESS
	1200	PNEU INSTL, MAIN FUEL TANK PRESS
	1205	ELEC EQUIP INSTL, STAGE

SATURN IB (contd.)

Model Number	Sect. No.	Title
DSV-4B-2-1	1210	ELEC EQUIP INSTL, FWD SKIRT
	1215	ELECT. EQUIP INSTL, PANEL MTD
	1220	ELECTRONICS ASSY, P/U
	1221	POWER AMPLIFIER, FM
	1222	CONTROL ASSY, POINT LEVEL TRANSDUCER
	1224	ELECTRONICS ASSY, STATIC, INVERTER CONVERTER
	1228	FAIRING UNIT ASSY, RANGE SAFETY RECEIVER, EBW
	1229	MTG ASSY, CONTROL DIST, FWD
	1230	MTG ASSY, POWER DIST, FWD
	1231	RECEIVER ASSY, RANGE SAFETY
	1232	CONTROLLER ASSY, RANGE SAFETY
	1233	TRANSLATER ASSY, SINGLE SIDEBAND
	1234	SUBCARRIER OSC & AMP ASSY
	1235	DIGITAL DATA ACQUISITION ASSY
	1236	MULTIPLEXER ASSY, PRIME-HIGH LEVEL
	1238	MULTIPLEXER ASSY, Bl-LEVEL
	1239	DECODER ASSY, CENTRAL, CABLE COMMAND
	1240	CALIBRATION ASSY, CENTRAL
	1242	RELAY ASSY, FM/DDAS
	1243	COUPLER ASSY, Bl-DIRECTIONAL
	1244	DETECTOR, RF POWER
	1245	TRANSMITTER, PAM/FM/FM
	1246	COAXIAL SWITCH, C/O MODULE
	1248	TRANSMITTER, SS/FM
	1249	TRANSMITTER, PCM/FM
	1250	DUMMY LOAD ASSY, RF, C/O MODULE
	1251	MULTIPLEXER ASSY, RF
	1252	POWER DIVIDER ASSY, RF, RS
	1253	POWER DIVIDER ASSY, RF, T/M

SATURN IB (contd.)

Model Number	Sect. No.	Title
DSV-4B-2-1	1256	NETWORK EXCITATION ASSY, 5V, INSTR
	1258	BATTERY INSTL, FWD SKIRT - S-IB
	1270	ELECT EQUIP INSTL, LH2 FWD DOME
	1271	FEED-THRU INSTL, WIRING INSTR-LH2 TANK
	1272	FEED-THRU INSTL, WIRING P. U.
	1280	ELECT EQUIP INSTL, LH2 TANK
	1282	SUPPORT INSTL, POINT LEVEL TRANSDUCER, LH2 TANK
	1283	PROBE INSTL, MASS, LH2 TANK
	1287	SUPPORT INSTL, WIRING, LH2 TANK
	1290	ELECT EQUIP INSTL, LO2 TANK
	1292	SUPPORT INSTL, POINT LEVEL TRANSDUCER, LO2 TANK
	1293	PROBE INSTL, MASS, LO2 TANK
	1320	ELEC EQUIP INSTL, AFT THRUST STRUC
	1328	SUPPORT INSTL, WIRING, THRUST STRUC
	1340	ELEC EQUIP INSTL, LO2 LOWER DOME
	1342	FEED-THRU INSTL, WIRING, LO2 TANK
	1360	ELEC EQUIP INSTL, AFT INTERSTAGE
	1362	SUPPORT INSTL, WIRING, AFT INTERSTAGE
	1364	DISCONNECT INSTL, ELECT, AFT I/STAGE - S-IB
	1366	DISCONNECT INSTL, UPPER ELEC
	1369	BOX INSTL, EBW, S-IB-SIVB SEP
	1400	ELEC EQUIP INSTL, AFT SKIRT
	1402	DISTR ASSY INSTL, CONTROL, AFT SKIRT
	1404	PANEL INSTL, ELECT EQUIP
	1405	ELEC EQUIP INSTL, PANEL MTD
	1407	BOX ASSY - ULLAGE ROCKET EBW FIRING UNIT
	1408	BOX ASSY, ULLAGE ROCKET JETTISON EBW FIRING UNIT

SATURN IB (contd.)

Model Number	Sect. No.	Title
DSV-4B-2-1	1410	SEQUENCER ASSY
	1416	BOX ASSY, FLT SEQ SWITCH SELECTOR
	1417	CONTROL ASSY, POINT LEVEL TRANSDUCER
	1418	INVERTER CHILLDOWN ELEC ASSY
	1420	BATTERY INSTL, AFT SKIRT -S-IB
	1424	DISTR ASSY INSTL, POWER, AFT SKIRT
	1380	WIRING INSTL, VEHICLE
	1390	ELEC SCHEMATIC, SYS, S-IVB, C-1B
	1392	ELEC SCHEMATIC, CONTROL SYS, C-1B
	1394	ELEC SCHEMATIC, INSTR SYS, C-1B ASV
	1396	HARNESS INSTL, CONTROLS
	1450	HYDRAULIC SYSTEM INSTL
	1460	PUMP, HYD, ENGINE DRIVER (SCD)
	1470	PUMP, HYD, AUX MOTOR DRIVEN (SCD)
	1510	VALVE, CHECK, HYD SYS (SCD)
	1530	ACTUATOR ASSY, HYD (SCD)
	1555	ACCUMULATOR RESERVOIR ASSY
	1480	VALVE, RELIEF, HIGH PRESS (SCD)
	1490	VALVE, RELIEF, LOW PRESS (SCD)
	1500	FILTER, HYDRAULIC, MAIN SYS (SCD)
	1650	INERT PARTS INSTL, DESTRUCT SYS
	1660	INERT PARTS INSTL, SEPARATION SYS
	1680	ENVIRONMENTAL CONTROL DISTR SYS-FWD INTERSTAGE
	1690	ENVIRONMENTAL CONTROL DISTR SYS-AFT INTERSTAGE
	1700	PROPULSION SYS INSTL, AUXILIARY
	1701	MAIN SUPPORT STRUCTURE INSTL
	1702	PROP TANKS INSTL
	1703	ENGINE PROP LINES INSTL
	1704	PRESSURIZATION SYS INSTL
	1705	AUTOMATIC LEAK CHECK INSTL

SATURN IB (contd.)

Model Number	Sect. No.	Title
DSV-4B-2-1	1706	ENGINE INSTL
	1707	AUTOMATIC LEAK CHECK INSTL.
	1712	DISCONNECT INSTL - AUXILIARY PROPULSION MODULE
	1714	SUPPORT INSTL, WIRING - AUXILIARY PROPULSION MODULE
	1711	INERT PARTS INSTL -C1-B ULLAGE ROCKET JETTISON
DSV-4B-2-2	1890	INTERSTAGE ASSY, AFT
DSV-4B-2-3	1912	ATTACHMENT KIT, ULLAGE ROCKETS, C-1B CONFIGURATION
DSV-4B-2-4	1917	EXPLOSIVE KIT, C1B ULLAGE ROCKET IGNITION
DSV-4B-2-5	1920	FAIRING NOSE COVER KIT, ULLAGE ROCKET, C-1B
DSV-4B-2-6	1910	ROCKET MOTOR, ULLAGE & RETRO
DSV-4B-2-7	1925	FAIRING KIT, ULLAGE ROCKET
DSV-4B-2-8	1930	EXPLOSIVE KIT, ULLAGE ROCKET JETTISON
DSV-4B-2-9	1935	ATTACHMENT KIT, ULLAGE ROCKET FAIRING

SATURN V

Model Number	Sect. No.	Title
DSV-4B-1-1	1000	SPACE VEHICLE, S-IVB STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1005	INSTRUMENTATION INSTL, STAGE
	1010	VEHICLE STRUCTURES ASSY, S-IVB
	1020	SKIRT ASSY, FWD
	1023	INSTL, T/M ANTENNA CABLE SYS
	1026	INSTL, R/S ANTENNA CABLE SYS

SATURN V (contd.)

Model Number	Sect. No.	Title
DSV-4B-1-1	1027	INSTL, T/M & R/S ANTENNAS
	1030	TANK ASSY, LO2 & LH2
	1075	THRUST STRUCTURE INSTL
	1060	SKIRT INSTL, AFT
	1080	TUNNEL INSTL, EXTERIOR
	1090	INSULATION INSTL, LH2 TANK
	1100	MARKINGS INSTL
	1110	PROPULSION SYS INSTL, COMPLETE
	1120	ENGINE INSTL
	1130	ENGINE CHILLDOWN INSTL
	1135	ENGINE CHILLDOWN MOTORS
	1140	PNEU SYS INSTL, AUTO LEAK CHECK
	1150	MAIN OXIDIZER TANK COMPONENTS INSTL
	1160	MAIN FUEL TANK COMPONENTS INSTL
	1170	PNEU INSTL, MAIN FUEL TANK RE-PRESSURE
	1190	PNEU INSTL, MAIN OXIDIZER TANK PRESS
	1200	PNEU INSTL, MAIN FUEL TANK PRESS
	1205	ELEC EQUIP INSTL, STAGE
	1210	ELEC EQUIP INSTL, FWD SKIRT
	1215	ELEC EQUIP INSTL, PANEL MTD
	1220	ELECTRONICS ASSY, P/U
	1221	POWER AMPLIFIER, F/M
	1222	CONTROL ASSY, POINT LEVEL TRANSDUCER
	1224	ELECTRONICS ASSY, STATIC, INVERTER CONVERTER
	1228	FIRING UNIT ASSY, RANGE SAFETY RECEIVER, EBW
	1229	MTG ASSY, CONTROL DIST, FWD
	1230	MTG ASSY, POWER DIST, FWD
	1231	RECEIVER ASSY, RANGE SAFETY
	1232	CONTROLLER ASSY, RANGE SAFETY

SATURN V (contd.)

Model Number	Sect. No.	Title
DSV-4B-1-1	1233	TRANSLATER ASSY, SINGLE SIDEBAND
	1234	SUBCARRIER OSC & AMP ASSY
	1235	DIGITAL DATA ACQUISITION ASSY
	1236	MULTIPLEXER ASSY, PRIME-HIGH LEVEL
	1238	MULTIPLEXER ASSY, BI-LEVEL
	1239	DECODER ASSY, CENTRAL, CALIB COMMAND
	1240	CALIBRATION ASSY, CENTRAL
	1242	RELAY ASSY, FM/DDAS
	1243	COUPLER ASSY, B1-DIRECTIONAL
	1244	DETECTOR, RF POWER
	1245	TRANSMITTER, PAM/FM/FM
	1246	COAXIAL SWITCH, C/O MODULE
	1247	TAPE RECORDER ASSY
	1248	TRANSMITTER, SS/FM
	1249	TRANSMITTER, PCM/FM
	1250	DUMMY LOAD ASSY, RF, C/O MODULE
	1251	MULTIPLEXER ASSY, RF
	1252	POWER DIVIDER ASSY, RF, RS
	1253	POWER DIVIDER ASSY, RF, T/M
	1256	NETWORK EXCITATION ASSY, 5V, INSTR
	1258	BATTERY INSTL, FWD SKIRT -SV
	1270	ELEC EQUIP INSTL, LH2 FWD DOME
	1271	FEED-THRU INSTL, WIRING INSTR-LH2 TANK
	1272	FEED THRU INSTL, WIRING P. U.
	1280	ELEC EQUIP INSTL, LH2 TANK
	1282	SUPPORT INSTL, POINT LEVEL TRANSDUCER, LH2 TANK
	1283	PROBE INSTL, MASS, LH2 TANK
	1287	SUPPORT INSTL, WIRING, LH2 TANK
	1290	ELEC EQUIP INSTL, LO2 TANK

SATURN V (contd.)

Model Number	Sect. No.	Title
DSV-4B-1-1	1470	PUMP, HYD, AUX MOTOR DRIVEN (SCD)
	1510	VALVE CHECK, HYD SYS (SCD)
	1530	ACTUATOR ASSY, HYD (SCD)
	1555	ACCUMULATOR RESERVOIR ASSY
	1480	VALVE, RELIEF, HIGH PRESS (SCD)
	1490	VALVE, RELIEF, LOW PRESS (SCD)
	1500	FILTER, HYDRAULIC, MAIN SYS (SCD)
	1650	INERT PARTS INSTL, DESTRUCT SYS
	1660	INERT PARTS INSTL, SEPARATION SYS
	1665	INERT PARTS INSTL, S-II RETRO ROCKET IGNITION
	1675	INERT PARTS INSTL, S-IVB RETRO ROCKET IGNITION
	1680	ENVIRONMENTAL CONTROL DISTR SYS-FWD INTERSTAGE
	1690	ENVIRONMENTAL CONTROL DISTR SYS-AFT INTERSTAGE
	1700	PROPULSION SYS INSTL, AUXILIARY
	1701	MAIN SUPPORT STRUCTURE INSTL
	1702	PROP TANKS INSTL
	1703	ENGINE PROP LINES INSTL
	1704	PRESSURIZATION SYS INSTL
	1705	AIR COND SYS INSTL, C-5
	1706	ENGINE INSTL
	1707	AUTOMATIC LEAK CHECK INSTL.
	1712	DISCONNECT INSTL-AUXILIARY PROPULSION MODULE
	1714	SUPPORT INSTL, WIRING-AUXILIARY PROPULSION MODULE
	1820	ELEC DETONATOR, EBW TYPE (SCD)
	1825	EXPLOSIVES KIT, SHAPED CHARGE SEPARATION
	1835	EXPLOSIVE KIT, DESTRUCT HARNESS
DSV-4B-1-10	1840	EXPLOSIVES KIT, S & A DEVICE
DSV-4B-1-12	1890	INTERSTAGE ASSY, AFT

2. TEST PROGRESSION AND LOCATIONS

a. Test Progression

The General Test Plan for the Saturn S-IVB System, Douglas Report SM-41412 provides an overall plan for program hardware testing at Santa Monica, Huntington Beach, Sacramento, and AMR to provide a satisfactory confidence level at minimum cost. The planned sequence of testing is as follows:

1. Research Testing
2. Development Testing
3. Qualification Testing
4. Production Testing
5. Flight Testing

A certain amount of research in cryogenics, radiation effects, vacuum environment, etc., is required before basic design decisions can be reached. After the basic material and processes are selected, design development testing and qualification testing on the component and subsystem level is initiated.

Production testing of flight stages begins at the component level and proceeds through subsystem testing to complete stage checkout. Component testing, therefore, begins in development testing and proceeds through qualification testing and production testing. Component testing is also performed as required to support flight testing operations at Sacramento and AMR.

b. Development Testing Phase

The development testing phase will provide information which can be applied to the design effort. Design weaknesses and performance degradation areas are identified during this phase. These tests will be of the breadboard type to assist in design completion. Major areas covered in this phase include Systems Integration Area testing and Battleship testing at Sacramento. During this phase components and subsystems capable of generating or susceptible to electromagnetic energy radiation will be electromagnetic compatibility tested.

Two examples of component testing in this phase follows:

1. Pneumatic and Hydraulic Components Testing

Proof and burst tests will be performed on production samples of all critical hydraulic and pneumatic components to ensure structural integrity. All specimens will be tested to destruction in the appropriate environment. Cycle tests will be performed on components where structural fatigue is a design consideration.

2. Flight Controls Components Testing

Development testing will be conducted with the engine gimbal control system using a full-scale laboratory functional mockup fixture. This fixture will simulate the complete engine positioning system as installed in the flight stage. Weights are provided to simulate engine inertia and the center of gravity. Structural spring rates are duplicated.

The test system is fully instrumented to obtain hydraulic systems fill and bleed procedures, hydraulic system pressure and flow characteristics, and dynamic data from open-loop frequency response tests using both servo actuators. System gain, stability, and response characteristics are defined using special laboratory servo test equipment.

c. Qualification Testing Phase

Qualification testing of parts, components, subassemblies, and higher levels of assembly is performed to ensure that the design is capable of meeting established requirements. Tests are designed to locate significant failure modes and to determine the effects of varied stress levels, combinations of tolerances, sequences, and environments.

An example of component testing in this phase follows:

Fuel Tank Vent and Pressurization Subsystems

A full-scale breadboard of the combined fuel tank pressurization and vent subsystems are tested at cryogenic temperatures. A source of -200°F gaseous hydrogen is used to simulate the J-2 engine bleed supply. The vent subsystem is tested to:

1. Substantiate the required pressurization system flow rates, and delivery pressures and temperatures.

2. Demonstrate fail safe operation of the pressurization and venting systems.

3. Verify the vent system flow capacity and response to both ground and "in flight" venting commands.

d. Production Testing Phase

All production stages, ground test stages, support equipment, and spare components are acceptance tested. Functional tests are normally conducted at room temperatures, but are operated under flight environments where such factors are critical.

Component Testing

1. Mechanical System components - fluid-carrying components of the stage hydraulic system, propulsion systems, auxiliary propulsion system, and environmental control are subjected to proof and leakage tests which exceeds normal system requirements. Operational tests are accomplished with functioning parts to ensure that design requirements are met.

Flight control hydraulic system components are thoroughly checked for cleanliness.

The engine driven hydraulic pump is selected as an example of production testing requirements. The hydraulic pump is classified as a critical item and has the following environments imposed during production testing:

a. Structural Testing at room temperatures.
b. Structural Testing at proof pressure.
c. Operational Testing at room temperature.
d. Operational Testing for leakage and flow.
e. Operational Testing, checking for contamination sensitivity

2. Stage Electrical Components - all stage electrical components are functionally tested and calibrated prior to installation. Testing is performed under room ambient conditions.

e. Locations

The components listed in Appendix D and E, i.e., Mechanical, Pneumatic and Hydraulic system components, are nearly 100% procured items and are DACO source tested at the vendor. The mechanical and pneumatic components when received at Douglas, are routed through the Douglas department for cleaning, testing and packaging of components for liquid oxygen and hydrogen systems prior to their installation on the stage at Huntington Beach. The hydraulic system components are routed through the Douglas Hydraulic Test Stand for air, water and oil tests prior to installation on the stage at Huntington Beach.

The stage electrical and electronic components that are procured are Douglas source tested at the vendor. The Douglas fabricated components are tested on component test sets prior to their installation on the stage at Huntington Beach. Any procured components that are modified at Douglas are tested on a component test set prior to installation on the stage. In general all electrical assemblies, procured by Douglas or fabricated by Douglas, are tested on the component test sets at Huntington Beach prior to their installation on the stage.

3. **FLOW RATE**

The flow rate of stage assemblies would generally follow the flow rate of the stage into which it assembles. A flow rate of the S-IVB stages is outlined in Figure 2. Also, manufacturing and test flow charts of the major electronic assemblies are shown in Figures 3, 4 and 5. In Figure 2 the manufacturing and assembly of Stage SA-201 (2001) spans approximately 16 months. In sequence, manufacturing of the next stage, SA-202 (2002) begins 2 months after the SA-201 (2001) start date and is completed 2 months after the SA-201 (2001) completion date. Scheduling follows a similar pattern in the succeeding stages. In Figure 3, selecting the P. U. Electronics assembly as a study of assembly progress, it may be observed that manufacturing and assembly requires approximately 2 to 3 months. One week is scheduled for checkout prior to the assembly being installed on the stage. The next P. U. Electronic Assembly to be tested is scheduled approximately 2 to 3 months later. This obviously is a very low rate of testing.

In general all stage electrical assemblies, mechanical and pneumatic components, hydraulic subsystems and modules proceed through a similar manufacturing and assembly cycle such that they are all scheduled for operational checkout and final sellout during an approximate four week period just prior to their Fwd and Aft Skirt installation on the stage. This cycle is then repeated for each succeeding stage.

Summarizing, the stage assemblies are all scheduled for checkout during the same period prior to installation on the stage, therefore, checkout is highly concentrated during a one to four week period with a lapse of two to three months between checkout periods.

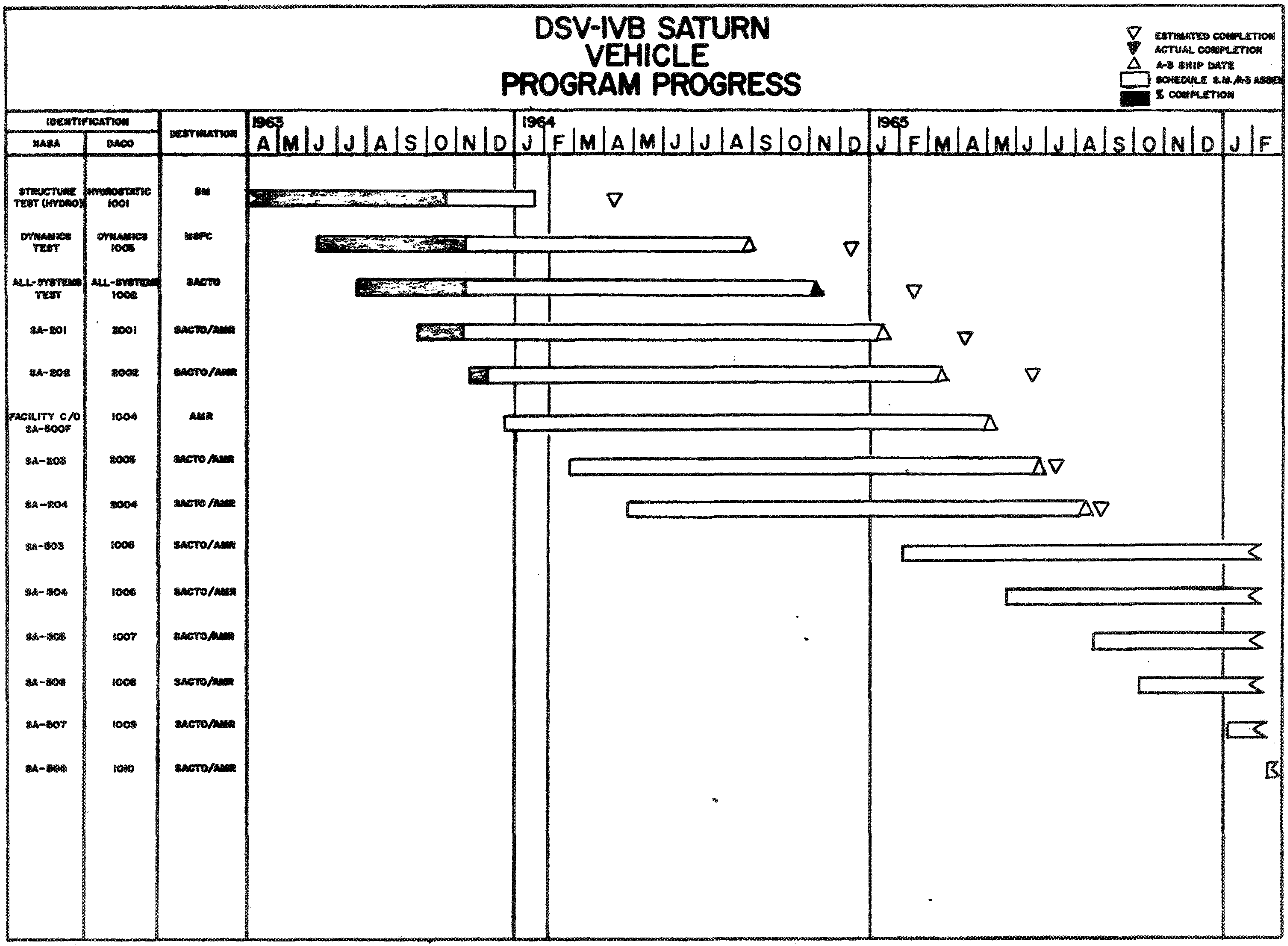
DSV-IVB SATURN
VEHICLE
PROGRAM PROGRESS
ESTIMATED COMPLETION
ACTUAL COMPLETION
A-3 SHIP DATE
SCHEDULE S.M./A-3 ASSE
% COMPLETION
IDENTIFICATION
NASA
DACO
DESTINATION
1963
1964
1965
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F
STRUCTURE TEST (HYDRO) HYDROSTATIC 1001 SM
DYNAMICS TEST DYNAMICS 1005 MSFC
ALL-SYSTEMS TEST ALL-SYSTEMS 1002 SACTO
SA-201 2001 SACTO/AMR
SA-202 2002 SACTO/AMR
FACILITY C/O SA-500F 1004 AMR
SA-203 2003 SACTO/AMR
SA-204 2004 SACTO/AMR
SA-503 1005 SACTO/AMR
SA-504 1006 SACTO/AMR
SA-505 1007 SACTO/AMR
SA-506 1008 SACTO/AMR
SA-507 1009 SACTO/AMR
SA-508 1010 SACTO/AMR

FIGURE 2

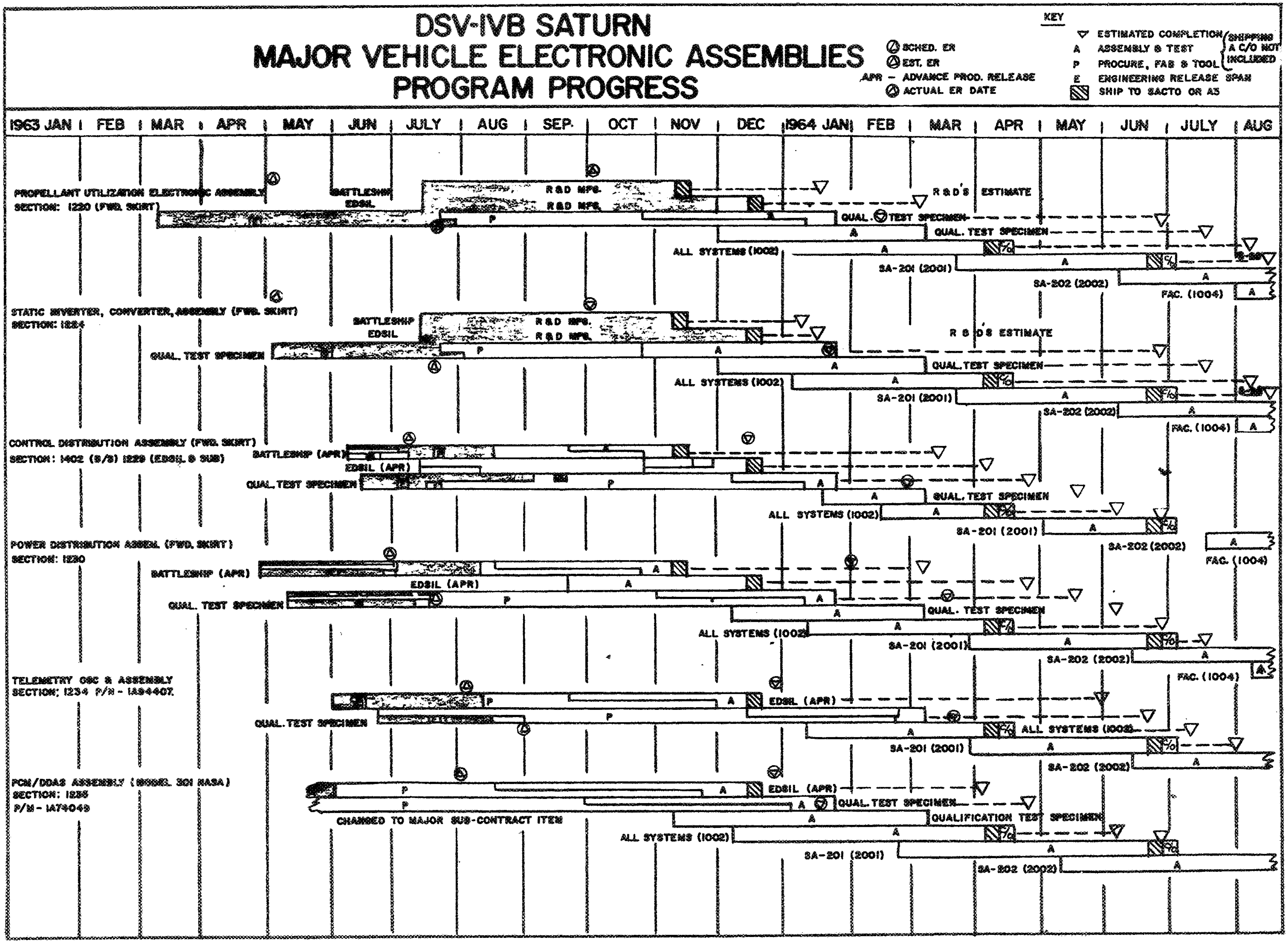
DSV-IVB SATURN
MAJOR VEHICLE ELECTRONIC ASSEMBLIES
PROGRAM PROGRESS
SCHED. ER
EST. ER
APR – ADVANCE PROD. RELEASE
ACTUAL ER DATE
KEY
ESTIMATED COMPLETION
A ASSEMBLY & TEST
P PROCURE, FAB & TOOL
SHIPPING A C/O NOT INCLUDED
E ENGINEERING RELEASE SPAN
SHIP TO SACTO OR A3
1963 JAN
FEB
MAR
APR
MAY
JUN
JULY
AUG
SEP.
OCT
NOV
DEC
1964 JAN
FEB
MAR
APR
MAY
JUN
JULY
AUG
PROPELLANT UTILIZATION ELECTRONIC ASSEMBLY
SECTION: 1220 (FWD. SKIRT)
BATTLESHIP
EDSIL
R&D MFG.
R&D MFG.
R&D'S ESTIMATE
QUAL. TEST SPECIMEN
QUAL. TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC. (1004)
STATIC INVERTER, CONVERTER, ASSEMBLY (FWD. SKIRT)
SECTION: 1224
BATTLESHIP
EDSIL
R&D MFG.
R&D MFG.
QUAL. TEST SPECIMEN
R&D'S ESTIMATE
QUAL. TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC. (1004)
CONTROL DISTRIBUTION ASSEMBLY (FWD. SKIRT)
SECTION: 1402 (S/S) 1229 (EDSIL & SUB)
BATTLESHIP (APR)
EDSIL (APR)
QUAL. TEST SPECIMEN
QUAL. TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC. (1004)
POWER DISTRIBUTION ASSEM. (FWD. SKIRT)
SECTION: 1230
BATTLESHIP (APR)
EDSIL (APR)
QUAL. TEST SPECIMEN
QUAL. TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC. (1004)
TELEMETRY OSC & ASSEMBLY
SECTION: 1234 P/N - 1A94407
EDSIL (APR)
QUAL. TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
PCM/DDAS ASSEMBLY (MODEL 301 NASA)
SECTION: 1236
P/N - 1A74049
EDSIL (APR)
QUAL. TEST SPECIMEN
CHANGED TO MAJOR SUB-CONTRACT ITEM
QUALIFICATION TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)

FIGURE 3

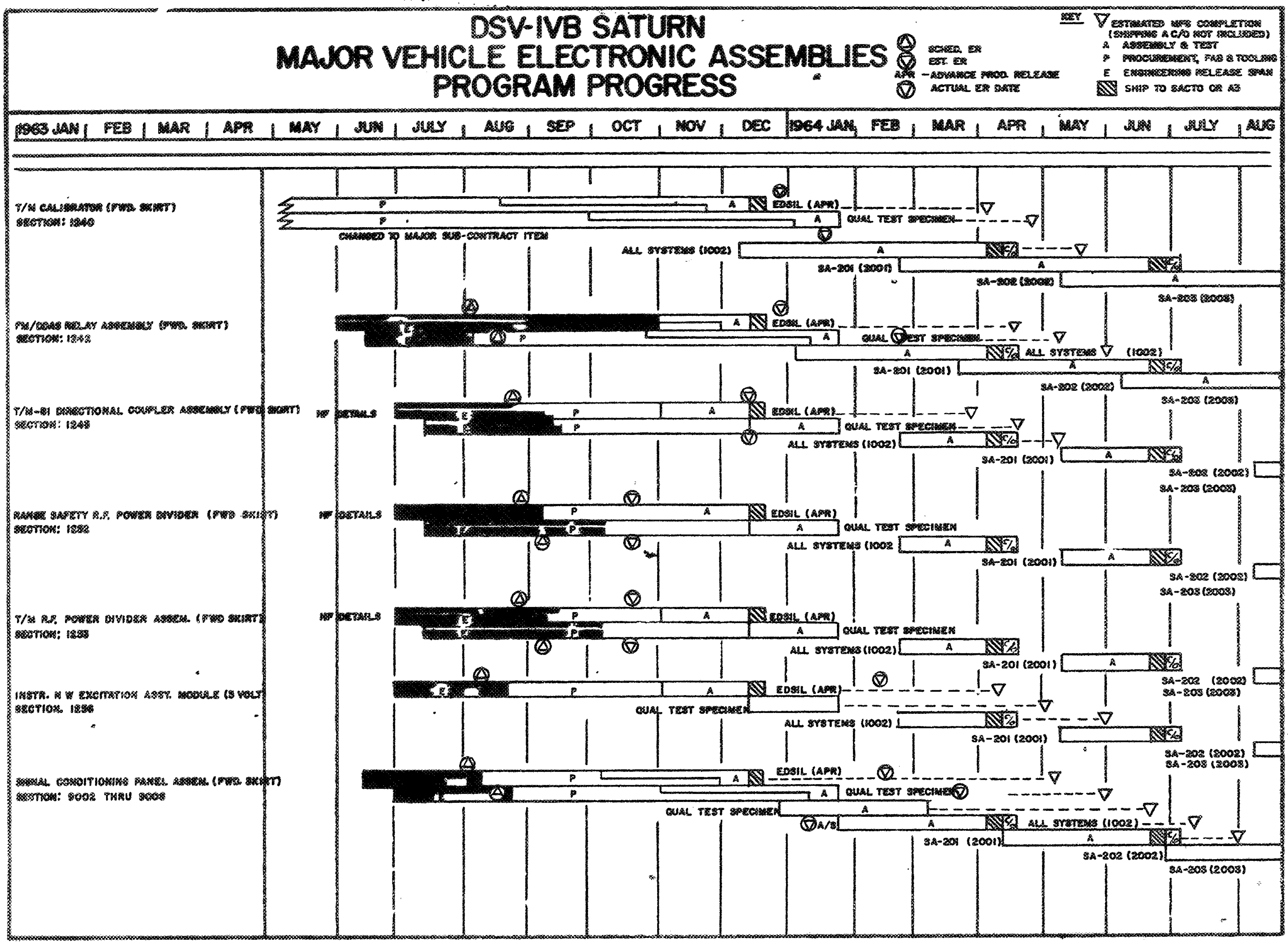
DSV-IVB SATURN
MAJOR VEHICLE ELECTRONIC ASSEMBLIES
PROGRAM PROGRESS
SCHED. ER
EST. ER
APR -ADVANCE PROD. RELEASE
ACTUAL ER DATE
KEY
ESTIMATED MFG COMPLETION (SHIPPING & C/O NOT INCLUDED)
A ASSEMBLY & TEST
P PROCUREMENT, FAB & TOOLING
E ENGINEERING RELEASE SPAN
SHIP TO SACTO OR A3
1963 JAN FEB MAR APR MAY JUN JULY AUG SEP OCT NOV DEC 1964 JAN FEB MAR APR MAY JUN JULY AUG
T/M CALIBRATOR (FWD. SKIRT)
SECTION: 1240
T/M-81 DIRECTIONAL COUPLER ASSEMBLY (FWD SKIRT)
SECTION: 1248
RANGE SAFETY R.F. POWER DIVIDER (FWD SKIRT)
SECTION: 1252
T/M R.F. POWER DIVIDER ASSEM. (FWD SKIRT)
SECTION: 1255
INSTR. N W EXCITATION ASSY. MODULE (5 VOLT)
SECTION. 1256
SIGNAL CONDITIONING PANEL ASSEM. (FWD. SKIRT)
SECTION: 9002 THRU 9008
CHANGED TO MAJOR SUB-CONTRACT ITEM
NP DETAILS
EDSIL (APR)
QUAL TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
SA-203 (2003)

FIGURE 4

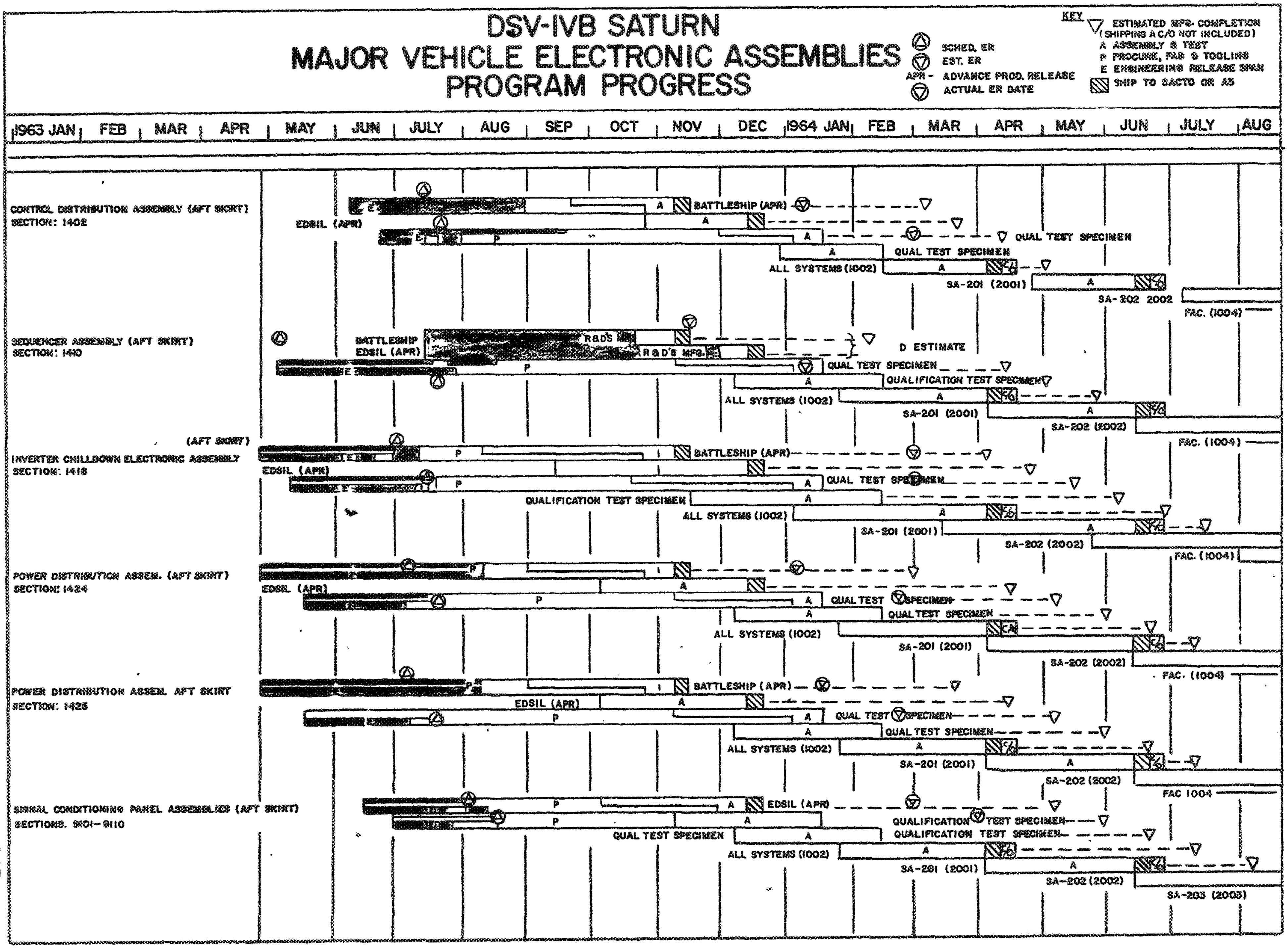
DSV-IVB SATURN
MAJOR VEHICLE ELECTRONIC ASSEMBLIES
PROGRAM PROGRESS
SCHED. ER
EST. ER
APR - ADVANCE PROD. RELEASE
ACTUAL ER DATE
KEY
ESTIMATED MFG. COMPLETION (SHIPPING A C/O NOT INCLUDED)
A ASSEMBLY & TEST
P PROCURE, FAB & TOOLING
E ENGINEERING RELEASE SPAN
SHIP TO SACTO OR AS
1963 JAN FEB MAR APR MAY JUN JULY AUG SEP OCT NOV DEC 1964 JAN FEB MAR APR MAY JUN JULY AUG
CONTROL DISTRIBUTION ASSEMBLY (AFT SKIRT) SECTION: 1402
BATTLESHIP (APR)
EDSIL (APR)
QUAL TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 2002
FAC. (1004)
SEQUENCER ASSEMBLY (AFT SKIRT) SECTION: 1410
BATTLESHIP
EDSIL (APR)
R&D'S MFG.
D ESTIMATE
QUAL TEST SPECIMEN
QUALIFICATION TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC. (1004)
INVERTER CHILLDOWN ELECTRONIC ASSEMBLY (AFT SKIRT) SECTION: 1418
BATTLESHIP (APR)
EDSIL (APR)
QUAL TEST SPECIMEN
QUALIFICATION TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC. (1004)
POWER DISTRIBUTION ASSEM. (AFT SKIRT) SECTION: 1424
EDSIL (APR)
QUAL TEST SPECIMEN
QUAL TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC. (1004)
POWER DISTRIBUTION ASSEM. AFT SKIRT SECTION: 1426
BATTLESHIP (APR)
EDSIL (APR)
QUAL TEST SPECIMEN
QUAL TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
FAC 1004
SIGNAL CONDITIONING PANEL ASSEMBLIES (AFT SKIRT) SECTIONS. 9101-9110
EDSIL (APR)
QUALIFICATION TEST SPECIMEN
QUAL TEST SPECIMEN
QUALIFICATION TEST SPECIMEN
ALL SYSTEMS (1002)
SA-201 (2001)
SA-202 (2002)
SA-203 (2003)

FIGURE 5

LISTING OF ALL TYPE A AND B GSE FOR SATURN S-IVB

1. The following is a list of Type A GSE:

Model Number	Sect. No.	Title	Effectivity
DSV-4B-102	2020	PAM/FM/FM TELEMETRY COMPONENT TEST SET	1, 2, 3
DSV-4B-103	2030	SS/FM TELEMETRY COMPONENT TEST SET	1, 2, 3
DSV-4B-104	2040	TEST SET, COMPONENT, PRINTED CIRCUIT CARD	1, 2, 3
DSV-4B-105	2050	COMPUTER, GENERAL PURPOSE	1, 2-5
DSV-4B-109	2090	SEQUENCER COMPONENT TEST SET	1, 2, 3
DSV-4B-110	2110	POWER SYSTEM ELEC COMPONENT TEST SET	1, 2, 3
DSV-4B-111	2120	TAPE RECORDER COMPONENT TEST SET	1, 2, 3
DSV-4B-112	2130	TEST SET, COMPONENT, P.U.	
DSV-4B-115	2160	PCM/FM T/M COMPONENT, TEST SET	1, 2, 3
DSV-4B-118	2190	COMPUTER INTERFACE UNIT	1, 2, 3, 4
DSV-4B-120	2210	SYS STATUS DISPLAY CONSOLE	X1
DSV-4B-121	2220	TEST OPERATOR CONSOLE	1, 2, 3, 4
DSV-4B-123	2240	GROUND STATION, DDAS	1, 2, 3, 4
DSV-4B-125	2260	PAM FM/FM T/M STATION	1-3
DSV-4B-126	2270	SS/FM T/M STATION	1, 2, 3
DSV-4B-127	2280	RECORDER, WIDE BAND, MAGNETIC TAPE	1, 2, 3, 4
DSV-4B-128	2290	RACK ASSY, FREQUENCY CALIB UNIT	1, 2, 3
DSV-4B-130	2310	CONDITIONER, STIMULI SIGNAL	1, 2, 3, 4
DSV-4B-131	2320	CONDITIONER, RESPONSE SIGNAL	1, 2, 3, 4
DSV-4B-132	2330	GSE TEST SET	1, 2, 3, 4
DSV-4B-133	2340	SIGNAL DISTRIBUTION BOX	1, 2, 3, 4
DSV-4B-134	2350	VEHICLE EXTERNAL POWER RACKS	1, 2, 3, 4
DSV-4B-135	2360	MONITOR, SAFETY ITEM	1, 2, 3, 4

TYPE A GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
DSV-4B-136	2370	TEST SET, DESTRUCT SYS	1, 2, 3, 4
DSV-4B-137	2380	EBW PULSE CHECKER	1, 2, 3-5
DSV-4B-139	2400	CABLE NETWORK KIT, AMR STAGE C/O AREA	1
DSV-4B-140	2410	CABLE NETWORK KIT, SIA STAGE C/O AREA	1X
DSV-4B-141	2420	CABLE NETWORK KIT, SM STAGE C/O AREA	1
DSV-4B-142	2430	CABLE NETWORK KIT, SACTO TEST STAND, BETA 1	1
DSV-4B-143	2440	CABLE NETWORK KIT, SACTO TEST STAND, BETA 2	1
DSV-4B-144	2450	CABLE NETWORK KIT, SACTO CONTROL ROOM, ALL SYSTEMS, AUTOMATIC	1
DSV-4B-145	2460	CABLE NETWORK, CONTROL ROOM, ACCEPTANCE	1
DSV-4B-146	2470	PATCH PANEL DISTR BOX, AMR STAGE C/O AREA	1
DSV-4B-147	2480	PATCH PANEL DISTR BOX, SIA STAGE C/O AREA	1 SET
DSV-4B-148	2490	PATCH PANEL DISTR BOX, SM STAGE C/O AREA	1
DSV-4B-149	2500	PATCH PANEL DISTR BOX, SACTO TEST STAND, BETA 1	1
DSV-4B-150	2510	PATCH PANEL DISTR BOX, SACTO TEST STAND, BETA 3	1
DSV-4B-151	2520	PATCH PANEL DISTR BOX, SACTO CONTROL ROOM, ALL SYSTEMS	1
DSV-4B-152	2530	PATCH PANEL DISTR BOX, SACTO CONTROL ROOM, ACCEPTANCE FIRING	1
DSV-4B-153	2540	RANGE TIME GENERATOR (SCD)	1, 2
DSV-4B-154	2550	PANEL ASSY-CONTROL LH_2 LOADING COMPUTER	1
DSV-4B-155	2560	PANEL ASSY-CONTROL, HYDRAULIC & GYMBAL	1
DSV-4B-156	2570	PANEL ASSY-HELIUM CONTROL	1
DSV-4B-157	2580	PANEL ASSY, CONTROL, LOX LOADING	1

TYPE A GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
DSV-4B-159	2600	RACK ASSY, CONTROL SWITCHING	1
DSV-4B-160	2610	RACK ASSY, UMBILICAL JUNCTION BOX	1
DSV-4B-161	2620	RACK ASSY, PATCH PANEL, JUNCTION BOX	1
DSV-4B-162	2630	PANEL ASSY, VEHICLE SYS POWER	1
DSV-4B-163	2640	PANEL ASSY, CONTROL, ENGINE FIRING	1
DSV-4B-164	2650	PANEL ASSY, ENGINE TEST COMPONENTS	1
DSV-4B-165	2660	CABLE NETWORK KIT, BLOCKHOUSE, B/SHIP	1
DSV-4B-166	2670	CABLE NETWORK KIT, TUNNEL, B/SHIP	1
DSV-4B-167	2680	CABLE NETWORK KIT, TEST STAND, B/SHIP	1
DSV-4B-168	2690	RACK ASSY, EXTERNAL, POWER NO. 1	1
DSV-4B-232	2696	CONSOLE, CONTROL, T/M SYS	1, 2, 3, 4
BSV-4B-233	2699	CONSOLE, CONTROL, REMOTE PNEUMATIC	1, 2, 3, 4
DSV-4B-234	2702	CONSOLE, CONTROL, DIGITAL PROP SYS	1, 2, 3, 4
DSV-4B-235	2705	CONSOLE, CONTROL, MANUAL PROP SYS	1
DSV-4B-236	2708	CONSOLE, CONTROL, ELEC NETWORK	1
DSV-4B-237	2711	CONSOLE, CONTROL, MECH SYS	
DSV-4B-238	2714	CONSOLE, DISPLAY, PROP SYS	1, 2, 3, 4
DSV-4B-239	2717	CONSOLE, DISPLAY, ELEC NETWORK	1, 2, 3, 4
DSV-4B-240	2720	CONSOLE, DISPLAY, T/M SYSTEMS	1
DSV-4B-241	2723	CONSOLE, DISPLAY, MECH SYSTEMS	
DSV-4B-243	2726	PROPELLANT LOADING SET, AUTOMATIC	1
DSV-4B-247	2739	PANEL ASSY, DIGITAL VOLTMETER & P. U.	1
DSV-4B-248	2741	P/U SYSTEM CALIBRATION UNIT	1

TYPE A GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
DSV-4B-249	2744	PANEL ASSY, CONTROL, GH_2/GH_2	1
DSV-4B-250	2747	INVERTER POWER SUPPLY, GROUND	1
DSV-4B-251	2750	GIMBAL POWER SUPPLY	1
DSV-4B-252	2753	TEST SET, TRANSMITTER	1
DSV-4B-253	2756	DISTRIBUTION COMPLEX, AUXILIARY SIGNAL	1, 2, 3, 4
DSV-4B-267	2798	SUBSTITUTE, INSTRUMENT UNIT	1, 2, 3, 4
DSV-4B-268	2801	SUBSTITUTE, S-II	1, 2, 3, 4
DSV-4B-269	2804	SUBSTITUTE, S-1B	
DSV-4B-270	2807	SUBSTITUTE, S-1C	
DSV-4B-271	2810	PANEL ASSY, CHILLDOWN INVERTER CONTROL	1
DSV-4B-276	2825	WEIGHT & BALANCE KIT, ELECTRONIC - AMR	
DSV-4B-277	2828	WEIGHT & BALANCE KIT, ELECTRONIC - A3	
DSV-4B-278	2831	GROUND STATION, PULSE CODED MODULATION	
DSV-4B-279	2834	INSTRUMENTATION C/O UNIT, VEHICLE	
DSV-4B-280	2835	MULTIPLEXER & CALIBRATOR COMPONENT TEST SET	1-3

2. The following is a list of Type B GSE:

Model Number	Sect. No.	Title	Effectivity
DSV-4B-300	3500	DOLLY TRANSPORTER, S-IVB STAGE, GROUND	1, 2
	3503	ELEC EQUIP INSTL, TRANSPORTER, S-IVB	
DSV-4B-301	3510	CRADLE, TRANSPORTER, S-IVB STAGE GROUND	1-6, 7-9
DSV-4B-302	3520	HANDLING KIT, STAGE	1-6, 7-10
DSV-4B-303	3530	HOIST KIT, FWD & AFT	1, 2
DSV-4B-304	3540	TIEDOWN KIT, PROTECTIVE, TRANSPORT	1-4
DSV-4B-305	3550	TOOL KIT, SPECIAL	1-6, 7-10

TYPE B GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
DSV-4B-306	3560	COVER, PROTECTIVE, SMALL ARMS	1, 2
DSV-4B-307	3570	HANDLING KIT, FLARED AFT INTERSTAGE	1-4
DSV-4B-308	3600	ACCESS KIT, FUEL TANK INTERIOR	1, 2, 3.
	3602	FIXTURE, LIGHTING	
	3603	FLOODLIGHT ASSY, FUEL TANK INTERIOR	
DSV-4B-309	3610	COVER, PROTECTIVE, FWD SKIRT END	1, 2
	3611	AIR DUCT KIT	
DSV-4B-310	3620	ACCESS KIT, VERTICAL, FWD SECTION	1-3, 4-6, 7-9
DSV-4B-311	3630	ACCESS KIT, VERTICAL, AFT SECTION	1, 2
DSV-4B-312	3660	HANDLING KIT, RETRO ROCKET	1-3
DSV-4B-313	3670	UMBILICAL KIT, AFT, STATIC TEST STAND	1, 2
	3671	INSTL KIT, PROP & PNEU LINES-AFT UMBIL, SACTO T/S II	
DSV-4B-314	3680	UMBILICAL KIT, FWD, STATIC TEST STAND	1, 2
	3681	INSTL KIT, VENT LINE GH_2, FWD UMBIL, SACTO T/S II	
DSV-4B-315	3690	UMBILICAL KIT, AFT, LAUNCHER	1, 2, 3
	3691	INSTL KIT, PROP & PNEU LINES-AFT UMBIL LAUNCHER	
	3693	CYLINDER, UMBILICAL	
DSV-4B-316	3700	UMBILICAL KIT, FWD, LAUNCHER	1, 2, 3
	3701	INSTL KIT, VENT LINE, FWD UMBIL, LAUNCHER	
DSV-4B-317	3710	DUAL VERTICAL CHECKOUT STAND	1
DSV-4B-318	3720	GAS HEAT EXCHANGER, (SCD)	1, 2, 3
	3723	ELEC EQUIP INSTL, GAS HEAT EXCHANGER	
DSV-4B-319	3730	OPERATIONAL PNEU CONSOLE "A" AUTOMATIC	1, 2, 3
	3731	CABINET, PNEU CONSOLE "A" AUTO	
	3733	ELEC EQUIP INSTL, PNEU CONSOLE "A"	

TYPE B GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
DSV-4B-321	3750	VEHICLE CHECKOUT PNEU CONSOLE	1, 2
	3751	CABINET, VEHICLE C/O PNEU CONSOLE	
	3753	ELEC EQUIP INSTL, VEHICLE CHECKOUT, PNEU CONSOLE	
DSV-4B-322	3760	OXIDIZER SERVICER, MOBILE-AUX PROP SYS	1
	3761	TANK ASSY, MOBILE SERVICER	
	3762	TANK ASSY, MOBILE SERVICER	
	3764	CABINET ASSY, MOBILE SERVICER	
	3764	SYS INSTL, PROP, MOBILE SERVICER	
	3765	SYS INSTL, PNEU, MOBILE SERVICER	
	3766	ELEC INSTL, MOBILE SERVICER	
	3767	CHASSIS ASSY, MOBILE SERVICER	
DSV-4B-323	3770	FUEL SERVICER, MOBILE - AUX PROP SYS	1
	3771	TANK ASSY, MOBILE SERVICER	
	3772	TANK ASSY, MOBILE SERVICER	
	3773	CABINET ASSY, MOBILE SERVICER	
	3774	SYS INSTL, PROP, MOBILE SERVICER	
	3775	SYS INSTL, PNEU, MOBILE SERVICER	
DSV-4B-323	3776	ELEC INSTL, MOBILE SERVICER	
	3777	CHASSIS ASSY, MOBILE SERVICER	
DSV-4B-324	3780	ALIGNMENT KIT, ENGINE	1, 2, 3
DSV-4B-325	3790	FIXTURE, ENGINE ACTUATOR ADJUSTMENT	1, 2, 3, 4, 5
DSV-4B-326	3800	ENVIRONMENTAL CONTROL SYS, AFT INTERSTAGE, SACTO	1, 2
DSV-4B-327	3820	OPERATIONAL & TEST STAND C/O PNEUMATIC CONSOLE "A"	1
	3821	CABINET ASSY, PNEUMATIC CONSOLE "A"	
	3822	CABINET, PNEUMATIC EQUIP	
	3823	ELEC EQUIP INSTL, PNEUMATIC CONSOLE "A"	

TYPE B GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
	3824	TRANSDUCER, TEMP	
DSV-4B-328	3830	OPERATIONAL & TEST STAND C/O PNEUMATIC CONSOLE "C"	1
	3831	CABINET ASSY, PNEUMATIC CONSOLE "C"	
	3832	CABINET, PNEUMATIC EQUIP	
	3833	ELEC EQUIP INSTL, PNEUMATIC CONSOLE "C"	
	3834	TRANSDUCER, TEMP	
DSV-4B-329	3840	CHECKOUT ACCESSORIES KIT	1
DSV-4B-331	3860	VALVE CONTROL, LO_2 COMPLEX	1, 2
	3863	ELEC EQUIP INSTL, LO_2 VALVE CONTROL COMPLEX	
DSV-4B-332	3870	LH_2 VALVE CONTROL COMPLEX	1, 2
	3873	ELEC EQUIP INSTL, LH_2 VALVE CONTROL, COMPLEX	
DSV-4B-333	3890	OPERATIONAL & TEST STAND C/O PNEU CONSOLE "B"	1
	3891	CABINET ASSY, PNEUMATIC CONSOLE "B"	
	3892	CABINET, PNEUMATIC EQUIP	
	3893	ELEC EQUIP INSTL, PNEU CONSOLE "B"	
	3894	TRANSDUCER, TEMP	
DSV-4B-334	3900	INSTL KIT, VENT LINE CH_2 UMBIL-SACTO	1
DSV-4B-335	3910	INSTL KIT, PROP & PNEU LINES - SACTO	1
DSV-4B-336	3920	TOOL KIT, PROP SYS MAINTENANCE	1
DSV-4B-337	3930	STAGE WEIGHT KIT, VERTICAL	1, 2
DSV-4B-338	3935	WEIGHT AND BALANCE KIT, FLARED AFT INTERSTAGE	1, 2
DSV-4B-339	3940	ALIGNMENT KIT, STAGE AFT SKIRT	1-3
DSV-4B-340	3945	ALIGNMENT KIT, INTERSTAGE TO S-II	1-3
DSV-4B-341	3950	HANDLING KIT, ULLAGE AND ATTITUDE CONTROL MODULE	1-3
DSV-4B-342	3955	HANDLING KIT, S-II RETRO ROCKET	1

TYPE B GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
DSV-4B-344	3970	HANDLING SLING, ATTITUDE CONTROL MODULE	1, 2
DSV-4B-345	3983	WEIGHT & BALANCE KIT, STAGE	1, 2
DSV-4B-346	3997	UMBILICAL KIT, AFT, CHECKOUT STAND	1-4
	3998	INSTL KIT, PROP & PNEU LINES, AFT UMBIL, C/O STAND	
DSV-4B-347	4001	UMBILICAL KIT, FWD, CHECKOUT STAND	1-4
	4002	INSTL KIT, VENT LINES-FWD UMBIL, C/O STAND	
DSV-4B-348	4006	ACCESS KIT, LOX TANK INTERIOR	1-3
	4007	ELEC EQUIP INSTL, LO_2 TANK INTERIOR	
DSV-4B-349	4009	HANDLING KIT, ENGINE	1, 2
DSV-4B-350	3960	HANDLING KIT, SOLID ULLAGE ROCKET	1, 2-4
DSV-4B-351	3975	WEIGHT AND BALANCE KIT, CONSTANT AFT INTERSTAGE	1
DSV-4B-352	3980	HANDLING KIT, CONSTANT AFT INTERSTAGE	1, 2-4
DSV-4B-353	3986	UMBILICAL KIT, AFT, LAUNCH COMPLEX 34	1
	3987	ELECT, INSTL	
	3988	INSTL KIT, PROP & PNEU LINES-AFT UMBIL, LAUNCH COMPLEX 34	
DSV-4B-354	3989	UMBILICAL KIT, FWD, LAUNCH COMPLEX 34	1
	3990	ELECT INSTL	
	3991	INSTL KIT, VENT LINE, FWD UMBIL, LAUNCH COMPLEX 34	
DSV-4B-355	3992	UMBILICAL KIT, AFT, LAUNCH COMPLEX 37A	1
	3993	ELECT INSTL	
	3994	INSTL KIT, PROP & PNEU LINES-AFT UMBIL, LAUNCH COMPLEX 37A	

TYPE B GSE (contd.)

Model Number	Sect. No.	Title	Effectivity
DSV-4B-356	3995	UMBILICAL KIT, FWD, LAUNCH COMPLEX 37A	1
	3996	ELECT INSTL	
	3999	INSTL KIT, VENT LINE-FWD UMBIL, LAUNCH COMPLEX 37A	
DSV-4B-357	4003	ACCESS KIT, VERTICAL CONSTANT AFT SECTION	1, 2
DSV-4B-358	4010	PUMPING UNIT, HYDRAULIC	1-3, 4, 5
DSV-4B-358	4011	ELEC EQUIP INSTL, HYD PUMPING UNIT	
DSV-4B-372	4076	CONTROL ASSY, VALVE COMPLEX, FUEL, AUX PROP SYSTEM	
	4078	BOX, VALVE	
	4079	ELEC EQUIP OXIDIZER AND FUEL VALVE COMPLEX, AUX PROP SYSTEM	
	4083	BOX, VALVE	
DSV-4B-374	4086	CONTROL ASSY, DISTR COMPLEX, PNEUMATIC, AUX PROP SYSTEM	
	4087	ELEC EQUIP, PNEUMATIC DISTRIBUTION COMPLEX, AUX PROP SYSTEM	
	4088	CABINET, PNEUMATIC DISTRIBUTION COMPLEX, AUX PROP SYSTEM	
DSV-4B-375	4091	CONTROL ASSY, REGULATION COMPLEX, PNEUMATIC, AUX PROP SYSTEM	
	4092	ELEC EQUIP, PNEUMATIC AUX PROP SYSTEM, REGULATION COMPLEX	
	4093	CABINET, PNEUMATIC REGULATION COMPLEX, AUX PROP SYSTEM	
DSV-4B-396	4195	AFT UMBILICAL KIT, C/O STAND, AMR, LOW BAY	1, 2
DSV-4B-397	4200	FWD UMBILICAL KIT, C/O STAND, AMR, LOW BAY	1, 2
DSV-4B-398	4205	AFT UMBILICAL KIT, C/O SYSTEM INTEGRATION LAB, A3	1X
	4206	CABLE ASSY, AFT UMBILICAL KIT, SIL - A3	
DSV-4B-399	4210	FWD UMBILICAL KIT, C/O SYSTEMS INTEGRATION LAB, A-3	1X
	4211	CABLE ASSY, FWD UMBILICAL KIT, SIL-A3	